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SPECIFICATIONS, RATES,

AND

NOTES ON WORK,

COMPILED FOR THE USE OF THE P. W. DEPARTMENT IN THE BOMBAY PRESIDENCY,

BY

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(1ST & 2ND EDITIONS)

AND

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(3RD & 4TH EDITIONS.)

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PREFACE.

FIRST EDITION.

THE principal object of this Compilation is to lay down a good standard set of specifications for use in the Public Works Department in the Bombay Presidency for all ordinary works, and a series of rates for such specifications. It is not to be supposed that the latter are perfect or absolutely correct; but it is believed that a tolerable approximation has been arrived at, and though owing to local causes it will not always be possible to work exactly to these rates, yet they form a useful standard for checking the amount of labour and materials used on works of various descriptions, or, if nothing more, a basis on which an accurate standard Rate Book can hereafter be framed.

In addition to this, sketches of Masonry, Brickwork, Carpentry, &c., have been added for the use of Maistries and others by whom the Roorkee Treatise and other larger and practical books are unobtainable, and some practical notes on various subjects have been compiled so as to form a handy Note Book.

An Index has been given to this edition, and some useful tables of Roofing by Major Seton, R. E.; and of dimensions of Doors and Windows by W. Howard, Esq., C. E., have been added.

If the Officers of the Department will only fill in, on interleaved copies, remarks on any practical points which they may have met with in their experience, as well as any suggestions for the modification or improvement of the specifications and rates, or for the introduction of any other subjects which may be usefully treated of in a work of this class, and will also kindly reduce all weights and measurements to lbs. and feet, instead of candies, maunds, &c., it is hoped that in a year or two a revised edition will be issued.

The following are the principal sources from which the specifications have been framed and notes compiled:—Standard Specifications, Oudh, by Captain Peile, R.E.; for Rájputána, by Lieutenant-Colonel Forlong; for Bombay, by Colonel Fuller, R. E.; Specifications of G. I. P. and B. B. and C. I. Railways; The Roorkee Treatise; The Chatham Course; Professional Papers on Indian Engineering; Engineers' Pocket Book; The Manufacture of Portland Cement, by H. Reid, C. S.

THIRD EDITION.

The second edition of this Compilation, which was published in 1877, has now been revised under the orders contained in Government Resolution No. 33 E—185, dated 6th February 1882.

The matter contained in this edition, both new and old, has been arranged somewhat differently to that of former editions. The whole Compilation has been sub-divided into twelve distinct sections, of which the first nine in number relate to different descriptions of work, as masonry, flooring, roofing, doors and windows, &c., &c. In each of these sections the specifications and rates follow each other instead of being separately massed together as in former editions, —an arrangement which, it is hoped, will facilitate reference.

The tenth section contains tables of scantlings of flooring timber, trusses, doors and windows, &c.; whilst the eleventh is devoted to notes on work.

The twelfth, or appendix, contains tables to facilitate the calculation of earth-work in cuttings and embankments, and of the areas of arch rings, segments, &c., in the masonry work of bridges and culverts.

The number of specifications and rates has been very largely increased. The most important addition in this respect is a set of standard specifications for use in the Irrigation Department which has been furnished by the Chief Engineer for Irrigation.

The specifications for rubble masonry have been carefully revised, and others added. Having been duly approved by Government they are now issued as standard specifications for this class of work. A large increase has also been made in the number of specifications and rates for roofing of different descriptions and of different spans.

FOURTH EDITION.

THE third edition of this Compilation, which was issued in 1883, has been revised under the orders contained in Government Resolution No. 237 A—1533, dated 16th September 1886.

The General Specifications which in the last edition were comparatively few in number and somewhat incomplete in other respects have been replaced by others taken from the "Standard Specifications in the Madras Presidency."

A new sub-head has been added, termed, "Drains, Culverts, and Bridges." The average plans and tables of quantities of which it consists are now published with the permission of J. H. E. Hart, Esq., M.Inst.C.E., Chief Engineer for Irrigation. This section is a re-print slightly amended of two very useful pamphlets "intended to facilitate the preparation of road projects in Executive "Engineers' offices," published by that officer in 1868.

Various corrections have been made in this edition in the Specifications and Rates in accordance with suggestions made by different officers of the Department. Several of the plans also, especially those relating to roofs, have been revised, and others substituted in place of those in the last edition which were incorrectly drawn, or defective in detail.

CONTENTS.

	Page of Specification.	Page of Rate.
I.—GENERAL SPECIFICATIONS.		
Clearing of Sites	1	
Dismantling of Buildings	1	
Carriage	1	
Quarrying and Blasting	2	
Earth-work	2	
Grassing, Turfing or Sodding	6	
Road Work	7	
Collection of Metal	7	
Spreading and Consolidation	8	
Maintenance	9	
Limes, Mortars and Cements	10	
Lime	10	
Sand	11	
Surki	11	
Mortar	11	
Pumice Mortar	12	
Mortar of Hydraulic Lime and Sand	12	
Cement Mortar	12	
Portland Cement	12	
Concrete	13	
General	13	
Pisé Work	14	
General	14	
Mud Plaster	15	
Brick and Tile Making	15	
Brick-work	16	
Brick in Chunam	16	
Brick in Mud	18	
Sun-dried Brick in Mud	18	
Stone Masonry	19	
General	19	
Ashlar	20	
Ashlar Walling	20	
Ashlar Facing	20	
Ashlar Arching	21	
Ordinary Stone or Rubble Work	21	
Coursed Stone Work	22	
Dressed Stone	22	
Stone Flagging	22	
Dry Rubble Work	23	
Dry Stone Pitching	23	
Dry Stone Revetment	23	
Rough Stone Ghát Revetment	23	
Plaster Work	24	
Rough Casting	24	
Cement Plaster	25	
Foundations	25	
Well-sinking	27	
For supply of Water	27	
For Foundations	28	

	Page of Specification.	Page of Rate.
I.—GENERAL SPECIFICATIONS—*continued.*		
Roofing...	28	...
Pucka Terracing	28	...
Arched Terracing	29	...
Double Tiled Roofing	29	...
Mangalore Tiling	30	...
Thatched Roofing	30	...
Corrugated Iron Roofing	31	...
Continuous Sheet Iron Roofing Galvanized	31	...
Zinc Roofing	32	...
Shingle Roofing	32	...
Tar and Sand for Terraced Roofs	32	...
Flooring	33	...
Brick on edge Flooring	33	...
Tile or Square Brick Flooring	33	...
Chunam or Terraced Flooring	33	...
Cement Concrete Flooring	33	...
Stone Flooring...	34	...
Asphalt Flooring	34	...
Tar and Sand Flooring	34	...
Minton's Tiled Flooring	34	...
Wooden Flooring	34	...
Metal Work	35	...
Iron Work	35	...
General	36	...
Erection	36	...
Painter's work	37	...
Glazier's Work	41	...
Plumber's Work	42	...
Drainage of Buildings	42	...
Wood work	44	...
II.—IRRIGATION BRANCH.		
Earthen Dam	47	...
Masonry Dam	50	...
Concrete in Dams	51	...
Masonry in Canal Drainage Works	52	...
Canal Banks	55	...
Laying Cast Iron Pipes	55	...
III.—MASONRY SPECIFICATIONS.		
Ashlar, Fine	59	71
„ Rough-tooled	59	72
„ Rock, Rustic or Quarry-faced	59	73
„ Chamfered	60	73
„ Facing	60	74 & 7
Block in course	60	76
„ Facing	61	76
Coursed Rubble, 1st Sort	61	77

	Page of Specification.	Page of Rate.
III.—MASONRY SPECIFICATIONS—*continued.*		
Coursed Rubble, 2nd Sort	62	78
„ „ 3rd Sort	63	79
Random Rubble, 1st Sort	63	80
„ „ 2nd Sort	64	80
Uncoursed Rubble...	64	81
Stone and Mud	65	82
Dry Stone	65	83
Dry Rubble Retaining Walls	65	84
Brick-work, 1st Class	66	85
„ 2nd Class	66	86
Brick and Mud	66	87
Brick Nogging	67	88
Arching.		
Ashlar	67	89
Block in course	68	90
Rubble...	68	91
Brick (Bridges)	68	92
„ (Doors, &c.), 1st Class	69	92
„ „ 2nd Class	69	93
Concrete.		
Road Metal or Shingle	69	94
Broken Brick and Kunker	69	95
Cement...	69	96
IV.—FLOORING SPECIFICATIONS.		
Paving, 1st Sort	99	107
„ 2nd Sort	99	108
„ 3rd Sort	99	109
„ 4th Sort	99	110
Paving (Upper Story), 1st Sort	100	111
„ 2nd Sort	100	112
Brick (flat)	100	113
Brick (edge)	100	114
Chunam or Terraced Floors	100	115
Asphalt flooring	100	116
Bastard Asphalt	101	117
Minton's Tiles	102	118
Wooden (Ground Floors)	102	119
Floor Planking	103	120
Single Flooring (Weight supported 140 lbs. per square foot) ...	103	121
„ „ („ „ 168 „) ...	103	121
Double flooring („ „ 140 „) ...	104	122
„ „ („ „ 168 „) ...	104	123
Composite Flooring, No. 1	104	124
„ „ No. 2	105	126

	Page of Specification.	Page of Rate.
V.—DOOR AND WINDOW SPECIFICATIONS.		
Door and Window frames	129	...
Doors.		
Doors, Panelled, 1st Class	129	134
„ „ 2nd Class	129	135
Doors, Panelled and Glazed, 1st Class	130	136
„ „ „ 2nd Class	130	137
Doors, Ledged or Battened	130	138
Doors, Framed and Braced	131	139
Doors, Iron-barred with Plank Shutters	131	140
Doors, Venetianed, 1st Class	131	141
„ „ 2nd Class	132	142
Windows.		
Windows, Glazed, 1st Class	132	143
„ „ 2nd Class	132	144
Windows, Plank Shutters	132	145
Windows, Iron-barred with Plank Shutters	132	146
Windows, Glass and Venetian Shutters, 1st Class	133	147
„ „ „ „ 2nd Class	133	148
Windows, Glazed, Iron Barred and plank Shutters	133	149
VI.—CEILINGS, PLASTERING, &c.		
Ceilings.		
Plank Ceiling	153	157
„ „ with Joists	153	158
Cloth Ceiling	153	159
Lath and Plaster Ceilings	153	160
Plastering.		
Plastering, rough, ¾″ thick	154	161
„ fine coat...	...	162
„ rough cast, ½″ thick	155	163
Brick rubbed rough Plaster	155	163
Cement Plastering	155	164
Pointing.		
Lime Pointing (Masonry)	155	165
„ „ (Brick Masonry)	155	165
Cement Pointing	156	166
VII.—ROOFING SPECIFICATIONS.		
Double Tiled Roof Covering.		
Double Tiling only...	170	182
Setting hips and ridges in chunam	170	183
„ double eaves in chunam	170	184
Eaves board	...	185

	Page of Specification.	Page of Rate.
VII.—ROOFING SPECIFICATIONS—*continued.*		
Double Tiled Roofing (Ordinary Construction).		
Roofing XII feet span	170	186
„ XIV „	170	187
„ XVI „	170	188
„ XVIII „	170	189
„ XX „	170	190
„ XXII „	170	191
„ XXIV „	170	192
„ XXVI „	170	193
„ XXVIII „	170	194
„ XXX „	170	195
Double Tiled Verandah Roofing.		
Roofing VI feet span	171	196
„ VIII „	171	197
„ X „	171	198
Double Tiled Roofing (Purlin Rafter Construction).		
Roofing XII feet span	171	199
„ XIV „	171	200
„ XVI „	171	201
„ XVIII „	171	202
„ XX „	171	203
„ XXII „	171	204
Corrugated Iron Roof Covering.		
Galvanized Iron Roof Covering	172	205
Rivetting and fixing Corrugated Sheets	172	206
Fixing Ridge	172	207
Corrugated Iron Roofing.		
Arrangement of sheets	208	...
Roofing XII feet span	172	209
„ XIV „	172	210
„ XVI „	172	211
„ XVIII „	172	212
„ XX „	172	213
„ XXII „	172	214
Terraced Roofing.		
Roofing VIII feet span	173	215
„ XII „	173	216
„ XVI „	173	217
Terraced Roofing Fire-proof	174	218
Miscellaneous Roofing, &c.		
Zinc Roof Covering	175	...
Belgaum Roof Covering	175	219
Taylor's Patent Tiles	175	220
„ „ Ridge and Hip Tiles	176	221

	Page of Specification	Page of Rate
VII.—ROOFING SPECIFICATIONS—*continued.*		
Miscellaneous Roofing, &c.—continued.		
Mangalore Tiles	177	222
„ Ridge Tiles	177	223
Goodwyn's Tiles	177	..
Atkinson's Tiles	177	...
Hill's Tiles	178	...
Syrian Roof as used in Sind	178	...
Wood Cement	178	...
Oropholite	179	...
Dammering on Roof	179	...
Gutters and Valleys of Sheet Lead	179	224
Valleys of Sheet Iron	179	225
Down Pipes	180	...
Ridge Ventilators (Howard's Pattern)	180	...
Lightning Conductors	181	...
VIII.—ROAD-WORK.		
Excavation in Black or Red Soil		229
„ in Soft Moorum		230
„ in Average Moorum		231
„ in Hard Moorum		232
„ in Loose Earth or Sand		233
„ in Soft Rock		234
„ in Hard Rock		234
Moorum, Digging, Conveying and Spreading		235
Moorum Watering and Rolling		236
Metal from Boulders, quarrying and breaking	7	237
„ from Blasted Rubble do.		237
„ Carrying and Stacking		238
„ Spreading and Picking up Surface	8	239
„ Consolidating with Ordinary Rollers		239
„ „ with Steam Rollers		240
IX.—MISCELLANEOUS.		
String course, cutstone, 1st Sort	243	247
„ „ „ 2nd Sort	243	248
Coping, cutstone, rectangular, 1st Sort	243	249
„ „ „ 2nd Sort	243	250
Coping, cutstone, semi-octagonal, 1st Sort...	243	251
„ „ „ 2nd Sort	243	252
Coping, cutstone, semi-circular, 1st Sort	243	253
„ „ „ 2nd Sort	243	254
Stone Steps	243	255
Stone Stairs	243	255
Wooden Staircase	244	255
Painting	244	256
Varnishing	245	257
Whitewashing	245	258

	Page of Specification.	Rate.
IX.—MISCELLANEOUS—*continued.*		
Yellow Wash	245	259
Blue Wash	245	260
Pink Wash	245	261
Green Wash	245	262
Papering	245	...
Glazing...	246	...
Tile Skirtings	246	...
Galvanized Iron Wire Netting..	...	263
Hoop Iron Trellis work	246	264
Teakwood do.	246	265
Laying Cast Iron Pipes, 10″ diameter	246	266
„ „ 6″ „	246	267
„ „ 4″ „	246	268
„ „ 3″ „	246	269
Grinding Mortar ...	...	270
Tile-making	...	270
Brick-making on Tables	...	271
„ on Ground	...	272
Lime burning with charcoal	...	273
„ with firewood	...	274
„ with English coal	...	275
Wire Fencing	...	276
Laterite and Lime (Foundations)	...	277
„ „ (Plinth)	...	278
„ Superstructure (Block in course)...	...	279
„ Arching over Doors and Windows	...	280
„ Paving	...	281
„ Cornice, 8″ high	...	282
„ Coping, semi-octagonal top, 8″ high	...	283
„ Laterite Concrete	...	284
„ Metal from Boulders...	...	284

X.—NOTES.	Page.
Stone	287
Brick-work	288
Plasters, Cements, &c.	290
Wood-work with a list of Principal Trees used in the Bombay Presidency.	300
Teak Trusses	303
Iron Trusses, with table of dimensions	303
Galvanized iron roof covering	305
Venetian Blinds	305
Paints, Washes, Varnishes, &c.	306
Code of Rules for the Erection of Lightning Conductors	310
Management of Portable Engines	312
Bridges ...	318
Pile-driving	319
Pipe-laying	320
Pumping	322
Boring	322
Knotting and Splicing	324
Concrete Arched Roofing	329
Instructions for using Dynamite	333
Sanitation of working Parties	337
Miscellaneous Notes	340

XI.—DRAINS, CULVERTS, AND BRIDGES.

	Page
Preface	347
Part I. Drains and Culverts	349
Do. Table I	363
Do. do. II	371
Do. Appendix	378
Do. Table A.	380
Do. do. B.	381
Do. do. C.	382
Do. do. D.	382
Do. do. E.	382
Do. do. F.	383
Part II. Bridges	384
Do. Table I.	391
Do. do. II.	401
Do. Appendix	406
Do. Table G.	407
Do. do. H.	409
Do. do. I.	410
Do. do. J.	411
Do. do. K.	412
Do. do. L.	413
Part III. Memorandum on the preparation of Road Project	413

XII.—TABLES.

Scantlings of Teak Joists	421
Do. do. do.	421
Do. do. Girders	422
Do. do. do.	422
Door Frames	423
Doors, Panelled	424
Do. partly Panelled and partly Glazed	425
Do. Batten	426
Do. Framed and Braced	427
Do. Framed Batten	428
Window Frames	429
Do. do. (Iron barred)	429
Windows, Glazed	430
Do. Venetianed	432
Do. Batten	433
Do. Iron barred with Glazed Shutters	434
Scantlings of Trusses	435
Do. Principals, Purlins, Rafters, &c.	436
Do. Double-tiled Verandah Roofs	437
Do. Single do. do. do.	438
Do. of Trusses for C. I. Roofs...	439
Straps and Bolts	439
Timber topped Culverts	440
Iron-work for do.	443
Burke's Tables of Task-work	445
Task-work in different soils	448
Conveyance by Coolies	450
Do. by Carts	451

Tables for the calculation of Earth-work.

First Series.

	Page
Base 18, Slope ½ to 1	455
„ 18 „ 1 to 1	456
„ 18 „ 1½ to 1	457
„ 18 „ 2 to 1	458
„ 20 „ ½ to 1	459
„ 20 „ 1 to 1	460
„ 20 „ 1½ to 1	461
„ 20 „ 2 to 1	462
„ 22 „ ½ to 1	463
„ 22 „ 1 to 1	464
„ 22 „ 1½ to 1	465
„ 22 „ 2 to 1	466
„ 24 „ ½ to 1	467
„ 24 „ 1 to 1	468
„ 24 „ 1½ to 1	469
„ 24 „ 2 to 1	470
„ 26 „ ½ to 1	471
„ 26 „ 1 to 1	472
„ 26 „ 1½ to 1	473
„ 26 „ 2 to 1	474

Second Series.

Base 1, Slope ⅓ to 1	475 to 482
„ „ 1 to 1	483 to 490
„ „ 1½ to 1	491 to 498
„ „ 2 to 1	499 to 506

Tables for calculating Areas of Arch-rings, Segments, &c.

General Table	507
Rise ⅛ and ⅓	508
Rise ¼ and ⅖	509
Rise ⅜ and ½	510

XIII.—APPENDIX.

Irrigation.

Useful Memoranda and Tables	511 to 519
Index	521 to 532

LIST OF PLATES.

	Facing Page.
I.—Masonry Dam	50
II.—Ashlar-work	59
III.—Rock Rustic Ashlar	60
IV.—Rubble-work	62
V.—Random Rubble and Brick Arches...	64
VI.—Brick Bond (English)	66
VII.—Do. do. (Flemish)	66
VIII.—Floor Boards	103
IX.—Doors, Panelled, Glazed, Ledged and Braced	130
X.— Do. Venetianed	131
XI.—Double-tiled Roofing (Ordinary Construction) ...	170
XII.— Do. do. (Purlin Rafter Construction) ...	171
XII-A.—Purlin Roof (showing different joints of Truss) ...	171
XIII.—Corrugated-iron Roofing	172
XIV.—Taylor's Patent Tiles	175
XV.—Mangalore, Goodwin's, and Atkinson's Tiles	177
XVI.—Hill's Tiles and Syrian Roof	178
XVII.—Ridge Ventilator (Howard's Pattern)	180
XVII-A.— Do. do.	180
XVIII.—Lightning Conductors	181
XIX.—Steps and Stairs	244
XX.—Pisé Box	295
XXI.—King Post Truss	303
XXI-A.—Queen Post Truss	303
XXII.—Joints, No. 1	303
XXIII.— Do. No. 2	303
XXIV.— Do. No. 3	303
XXV.—Iron Trusses	304
XXVI.—Details of do.	304
XXVII.—Boring Tools	322
XXVIII.—Knots, No. 1	324
XXIX.— Do. No. 2	326
XXX.—Lashings	328
XXXI.—Concrete Roof (Plan)	332
XXXII.— Do. do. (Sections)	332
XXXIII.— Do. do. do. (Details)	332
XXXIV.—Hanging Punkahs	344
XXXV.—Sections of Ground	453
XXXVI.—Figures of Drains and Bridges, centrings, &c.	382
XXXVII.—General Drawing of wing walls of Drains	382
XXXVIII.—Details of Parapets, Piers, and copings for Drains ...	382
XXXIX.—1 and 1½ Feet Slab-Drain	382
XL.—2 and 2½ do. do.	382
XLI.—3 Feet Slab-Drain	382
XLII.—3 Do. Culvert	382
XLIII.—4 Do. do.	382
XLIV.—5 Do. do.	382
XLV.—6 Do. do.	382
XLVI.—8 Do. do.	382
XLVII.—10 Do. do.	382
XLVIII.—General Drawing of wing walls for Bridges	412
XLIX.—15 Feet Bridge	412
L.—20 Do. do.	412
LI.—25 Do. do.	412
LII.—30 Do. do.	412

I.—GENERAL SPECIFICATIONS.

I.—CLEARING OF SITES.

1. The area described and shown on the plan, to be cleared of all trees and brushwood, the roots being entirely grubbed up.

2. The products of the clearing to be stacked in such place and manner as may be ordered by the Executive Engineer or his agents, and the ground left in a perfectly clean condition.

3. In jungle clearing, all trees not specially marked for preservation, bamboos, junglewood, and brushwood, are to be cut down and their roots grubbed up. All wood and material from the clearing to be the property of Government, and to be disposed of as the Executive Engineer may deem fit.

4. All holes or hollows, whether originally existing or produced by digging up roots, are to be carefully filled up with earth, well rammed and levelled off, as may be directed.

II.—DISMANTLING OF BUILDINGS.

1. The buildings, sheds, huts, walls, or other structures, described and shown on the plan, to be dismantled down to ground level. Special care to be taken that the materials are as little damaged as possible in the process of dismantling.

2. All serviceable materials to be removed to indicated positions, where they will offer no impediment to the progress of work, and where they will be stacked in convenient lots, and will be the property of Government.

3. All mere rubbish to be collected in heaps on the site of the dismantled buildings, for disposal as may be necessary.

III.—CARRIAGE.

1. The rates for carriage will include all cost of loading and unloading in ordinary cases, and, as a rule, of stacking the material in regular heaps on the ground to which it is brought.

2. Carriage may be contracted for by weight or bulk at a mileage rate or at a fixed rate between specified places. In the former case, the distance will be measured by the nearest practicable route.

3. When carts are engaged by the day, the quantity of material to be conveyed, and the distance to be travelled, or number of trips to be made, will be fixed by the Executive Engineer.

4. Contractor or cartman to make good all loss of any sort that may occur in removing and transporting material entrusted to him, whether caused by wastage, breakage, or other cause, unless otherwise specially provided.

IV.—QUARRYING AND BLASTING.

1. All stone to be sound, free from decay, flaws, cracks, veins, or cavities, and so far as possible of uniform color and texture.

Granite or gneiss near the surface which has been exposed to atmospheric influences and shows any tendency to disintegrate, and that in which feldspar and mica predominate, should on no account be used. The quarries from which the stone is to be obtained will be indicated by the Executive Engineer.

2. Blocks required for dimensioned stuff must be quarried true and square, and as near the dimensions given as possible.

3. Rubble stone will be as square and evenly bedded as possible, and in as large pieces as the quarry will permit consistently with facility of being handled. No irregularly-shaped or unevenly-bedded pieces shall be permitted, and no stone shall contain less than $\frac{1}{3}$ of a cubic foot.

4. Porebandar stone is to be of fine grain, good colour and free from salt. No Porebandar stone of doubtful quality, or of very coarse grain, or with black specks in it to be brought on the work, and if it has been at any time saturated with sea-water, it will be rejected.

5. Laterite should be compact in texture, and the mottled and streaked colors pervading it should not be very unevenly distributed. Those descriptions in which the sinuosities are numerous and deep, as well as those in which white lithomargic earth occurs, should not be used as building material. Laterite being benefited by long exposure, should never be used when freshly quarried, especially from any depth. It should not be used where subject to great pressure, or where likely to be exposed to a run of water.

6. When quarrying or blasting is being carried on, no mine shall be loaded or fired save under the personal superintendence of a European or experienced Native subordinate or other competent person approved by the Executive Engineer, who will be held responsible that every precaution is taken to prevent accidents to life or property.

7. When the blasting takes place in a frequented place, or near a public road, all mines should be fired at a certain fixed time, and vedettes with red flags thrown out to warn all passers-by.

8. The officer or subordinate in charge of mining or blasting operations will be held strictly responsible for the safe custody and storage of the powder, dynamite, or other explosives on the works.

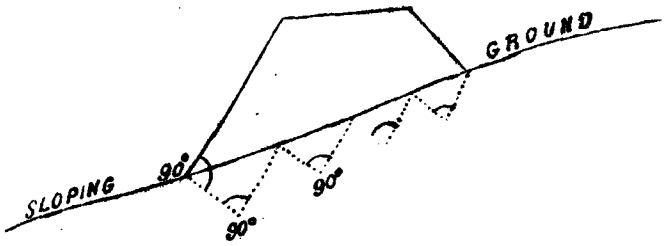
V.—EARTHWORK.

1. Before the earthwork of any embankment is commenced, the ground to be occupied by its base will be thoroughly cleared of all

trees, shrubs, grass, rubbish of all sorts, loose stones, and soft stuff, and stumps and roots entirely grubbed up. Prickly-pear must be buried under not less than 2 feet of earth. The removal of stumps and roots of bamboos should be carried out by special agreement.

2. When ordered, the top mould on the site of the embankment shall be carefully removed and stored until the earthwork is completed, when the soil so obtained shall be neatly spread over the slopes of the embankment.

3. The surface of sloping ground on which an embankment is to be erected shall invariably be prepared to receive the earthwork, by having cut in the slope a sufficient number of footings or benches forming a right angle with the slope of the embankment as per following sketch :—



4. Excavations from which earth is procured for embankments must be confined to the positions indicated by the Executive Engineer. In no case shall the edge of such excavations be nearer to the toe of the embankment than 10 feet for every 3 feet in depth of the excavation.

5. Before commencing any embankment, the foot of the slopes on each side will be marked by pegs firmly driven into the ground at intervals of twenty feet, then, care being taken to place them at right angles to the centre line, profiles made of bamboo or other convenient material and string, or, if desired, earth sections, will be set up for the guidance of the workmen, at such intervals along the embankment as the Executive Engineer deems necessary. The profiles will show the total height including allowance for settlement.

6. No mud, slush or watery stuff from wells or springs, and no decayed vegetable matter or rotten stuff of any kind, shall be allowed to be put into embankments. All such material taken out of excavations shall be placed on one side, or used to fill up excavations no longer required.

7. All embankments are to be raised (after the site has been properly prepared and well watered) in regular layers slightly concave in section. The base of the embankment is to be made of its full width at first, and the earth is to be thrown down from the sides toward the centre, not *vice versâ*. The layers will be of the thickness fixed by the Executive Engineer, and will be rammed and consolidated by using water if so directed by him. They will be carried out to the full width of the slopes in all instances, so that no additions may be required to the slopes after the bank is up to formation level.

8. All lumps and clods of earth are to be broken up, so as to allow of a regular subsidence of the earthwork throughout.

9. Embankments of black cotton soil will be constructed with such proportion of sand or other material well mixed as the Executive Engineer may direct.

10. In carrying up embankments, the full allowance for shrinkage shall be made at first, as may be laid down for the specific class of soil by the Executive Engineer, so that no addition of earth will be required after settlement to bring the bank up to its full dimensions.

11. Unless otherwise directed, the following allowances will be made for shrinkage of earthwork :—

In firm compact earth	...	...	$1\frac{1}{2}$ inches per foot.
In ordinary loose earth	...	...	2 „ „
In black cotton soil ...	...	...	3 „ „

12. The tops of all embankments are to be brought up to the levels set out by the Executive Engineer (including the allowances for shrinkage), and be neatly levelled off. The slopes are to be dressed to the required inclination and neatly trimmed.

13. In carrying embankments over a bridge or culvert intended to be covered in, the earthwork shall be brought up evenly on both sides of the structure, so that the pressures may be equalised. In filling in the approaches of a bridge, or the spandrils between small arches, the earth shall be raised simultaneously with the wing walls in the former case and with the face walls in the latter, in order that the filling in may be well trodden down under the feet of the labourers ; and in filling in basement and backings to revetments, the earthwork shall similarly be brought up level as the masonry proceeds.

14. When new embankments are joined to old, the old work surface is to be removed to a slope, and the junction to be dug up 2 feet deep, and both new and old stuff well watered and rammed.

15. Ditches, holes, &c., may be filled up at random and earth added after settlement takes place, to level and finish the job.

16. In the case of long slopes, or where a cutting is in sidelong ground, or where from any other reason there may appear to be risk of slips taking place, benches shall be formed in the positions and of the dimensions directed by the Executive Engineer. These benches shall be horizontal and be neatly dressed to a level surface.

17. Unless otherwise ordered, in cutting through high ground the excavation shall be made in steps down to formation level with sides perpendicular, or nearly so, and the slopes formed afterwards.

18. The sides of cuttings for roads in loose soil are to be protected by catch drains above the cuttings, or by surface drains running diagonally at such inclination down the slope, as may be ordered by the Executive Engineer. At the foot of the slope will be a small berm, and between this and edge of formation level a catch-water drain of dimensions to be fixed in each case by the Executive Engineer.

19. The side cuttings for the formation of road embankments are to be of a regular rectangular outline, parallel to the center line of the road and of uniform width, unless the depth at any point would exceed four feet, in which case the width may be increased. Irregularly-shaped pits are on no account to be allowed.

20. Unless intended to be used as side or catch drains, the side cuttings shall not be continuous, but regular rectangular bars, ten feet wide, shall be left at intervals of 100 feet.

21. When intended to be used as side or catch drains, the side cuttings shall be carefully trimmed and formed to the proper dimensions, and with the inclination of bed fixed upon by the Executive Engineer.

22. In making cuttings, care shall be taken not to injure or interfere with irrigation channels, tank embankments, roads, &c. Temporary arrangements must always be made for carrying irrigation or drainage water across cuttings until the permanent arrangements have been completed.

23. Earth from cuttings, when not required to be led into embankments, shall be taken to spoil within limits fixed upon by the Executive Engineer, and shall be the property of Government.

24. The spoil is not to be thrown up in irregular, shapeless heaps, but formed into a regular bank, of uniform height, so far as possible, with a level surface and with slopes of 1½ to 1, as may be ordered by the Executive Engineer. In the case of channel or river spoil banks, their top surfaces must be sloped away from the channel so as to prevent drainage from flowing over and forming gullies down the slopes and berms.

25. Small walls or ridges of earth shall be thrown up along the sides, as well as similar transverse ridges at suitable distances, on the top of the bank, to hold the rain-water and allow of the consolidation of the earth.

26. All "dead men" are to be removed from cuttings when no longer required for measurement purposes. All temporary pathways, ramps, &c., are to be dressed off neatly and the whole work properly finished. These works are to be carried out by the contractor within the over-all rates.

27. The measurements of earthwork will be taken from the pits furnishing the earth, or by the estimated quantities at the discretion of the Executive Engineer.

28. When the earth is obtained from pits these are to be numbered, the numbers being marked on pegs driven into the corner of each pit to facilitate check measurement. Pits moreover should if possible be of an uniform size, and the "dead men" should not be removed till the final measurements have been made and passed.

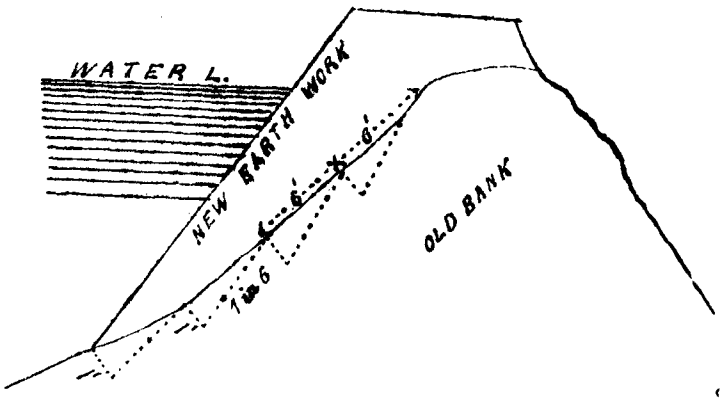
29. In filling an excavation or hollow, the horizontal lead only is to be allowed, and the lead will be measured from the centre of gravity of the cutting or mass of earth moved to the centre of the hollow.

30. In valuing the work, one foot of vertical lift shall be taken as equal to ten feet of horizontal lead.

31. When earth has to be carted, the excavation will be paid for without lead, and the carriage separately paid for according to schedule rates.

32. Contractors are personally responsible for all damage they may cause to private property (such as buildings, wells, trees, &c.) in the execution of their work. They must also, excepting in special cases, make their own arrangements with the owners of land for "getting" or stacking earth, gravel, &c., as may be required.

33. The repairs and additions to existing embankments to be carried out on the same general principles as new banks; the new work in case of additions to tank or flood banks is invariably to be placed on the inner or water side of the old bank, the inner face of which will be prepared for the reception of the new work by being cut into steps with a rise of one foot, and with the treads sloping outwards towards the old bank at a slope of one in six as per following sketch :—



34. Puddle is to consist of suitable, clean, tough, retentive clay, freed from all large stones and vegetable matter, and compounded with as much sand or fine gravel as will make it sufficiently tenacious to hold water. It should be used in nine-inch thick layers, with sufficient water to reduce it to the consistency of paste or pap, and well worked up with powrahs and men's feet until it becomes a perfectly uniform and compact mass. The layers of the puddle to be kept as uniform and level as possible, and never on any account to be allowed to dry. Should the surface of the puddle crack at any time, the cracked surface is to be dug up and the puddle remade.

VI.—GRASSING, TURFING, OR SODDING.

1. The sides of embankments, slopes, and of cuttings, when required, will be soiled and turfed, sown, or planted with grass of approved descriptions. This must always be done at such time as to allow of at least one entire season's rain to fall, before the termination of the contract, when the work will be made over by the contractor.

2. When slopes or tops of bunds have to be turfed or sodded, the sods will be cut to rectangular dimensions, defined by the Executive Engineer; and in laying them on, their edges must be brought in as close contact with each other as possible by manipulation and then

welded, by being gently beaten with wooden rammers, so as to form a level, compact, and unbroken bed. The surface of ground to receive sodding will be picked about 1½ inches deep to give a rugged back and thereby afford a hold to the sodding.

3. When grass seed is sown, it should not be cast indiscriminately; but furrows parallel or nearly so to the top of the embankment will be raked out, and the seed deposited therein. The operation of grassing shall not be considered completed until the seed begins to sprout; the cost of watering until this takes place, and for as much longer as may be found necessary according to the season, will be borne of course by the contractor. Live roots will be planted in parallel rows also, and watered until they hold, and show signs of growth.

4. The description of grass used for the above purposes shall not be the long, lank, sedgy description, but of the dwarf family, that grow in masses and are singularly tenacious, generally known as Doab grass.

VII.—ROAD WORK.

1. Collection of Metal.

1. The quarries from which road material of whatever kind is obtained must be approved by the Executive Engineer or his authorised representative.

2. The metal shall be of a close, tough, hard texture, and be broken so as to pass in every direction through a 2-inch ring for under-layers and through a 1½-inch ring for the surface. Each piece should be square and sharp; no round or oblong pebbles, no angular chips or flakes, and no stones larger than what is above specified shall on any account be used.

3. Laterite for road metal should be hard, compact, heavy, and of a dark color. The lighter colored sandy laterites as well as those containing much ochreous clay, should be rejected. Laterite which approaches hæmatite in quality is the best material to be used.

4. Gravel should be composed of large, coarse, silicious grains, sharp and gritty to the touch, and thoroughly free from dirt and impurities. The pebbles composing laterite gravel should be separated from the excess of clay which usually accompanies them before being used as gravel. Sand used for blinding road surfaces should be sharp, gritty, and clean, and the quantity used shall not exceed half an inch in depth.

5. Moorum shall be good, hard and clean, approved by the Officer in charge of the work.

6. No road material shall be stacked, until it has been thoroughly screened and freed from all earth, &c., and, when ready, must be stacked entirely clear of the roadway either upon the berms and platforms provided for the purpose, or at the foot of the side slopes.

7. Road material will be stacked in long, continuous heaps, of such size and uniform dimensions throughout that each running yard will contain the quantity required for a running yard of roadway, or, if in separate heaps, of such dimensions as may be directed by the Executive Engineer. It has been found convenient in practice to adopt uniform and separate heaps of twenty cubic yards for special repairs, and of five cubic yards for petty repairs.

8. When the continuous line of the stack is interrupted by any obstacle, a second stack of the proper section and of the length of the gap shall be placed alongside the main one, or in other convenient position adjacent to the gap.

9. When material for two coats has to be stacked, as in the case of a new road, the material for the two coats, unless otherwise ordered, shall be stacked on opposite sides of the road.

10. In stacking material, the depositing shall commence at one end of the mile and be carried continuously towards the other end, unless the Executive Engineer shall direct otherwise, and as a rule measurements will not be taken until sufficient for a furlong, half mile, or mile has been fully collected, and fractions of those distances will not be measured up.

11. Metal, &c., collected for petty repairs, shall be stacked on the opposite side to that where the material for renewals is stored, and the form of the heaps shall be such as to distinguish them at once from the metal collected for new work.

12. All road material shall be examined and measured before it is spread, and immediately on being paid for shall be marked by white-wash or otherwise as may be directed by the Executive Engineer (at the contractor's expense) to prevent the possibility of being paid for over again. As a rule, collecting and spreading must not be carried on at the same time on one and the same mile, or on two adjoining miles.

13. Excavations for gravel, earth, &c., will not be less than 12 yards from the centre of the road. The pits so formed shall be trimmed to such form as may be ordered, and, if possible, drained.

14. The Executive Engineer will supply the contractor with a statement, mile by mile, of the quantities of metal that will be required and with written instructions concerning the particular localities in which the metal is to be stacked, as well as those in which the collections are to be first made.

15. The contractor shall be bound to make progress in collection of metal at a certain minimum speed, proportional to the quantity to be collected, to be at the time agreed upon between him and the Executive Engineer, as also to remove all material that may be rejected to such distance as may be ordered, within 48 hours after receiving written instructions so to do from the Executive Engineer.

2. Spreading and Consolidation.

1. Before spreading the metal, the surface of the road will be picked up $1\frac{1}{2}$ inches deep, and the loosened material will be removed to the sides and used to form up the side bands outside the central metalled formation.

2. The new metal will then be carefully spread between the side bands, the larger pieces being placed at bottom and the smaller at top. The surface will be laid with a regular curve with central rise of 2″ for 16′ width.

3. To ensure correctness, wooden templates, the exact size and shape of the new coat, will be laid on the old surface at regular distances apart, and the metal will be laid to them.

4. The new metal will then be consolidated by rolling, being thoroughly saturated with water if the rain falling proves insufficient, and will be continued until the surface is thoroughly hard and smooth: no more "blinding" of sand and moorum being used than is absolutely necessary to ensure the metal binding. The weight of the rollers should be at least $\frac{3}{4}$ of a ton per foot of length. Over this, as a finishing coat, a thin layer of sand is useful.

N.B.—Ramming is of little use unless performed with a large force, sixteen men working in four consecutive rows, using abundance of water. The work of each portion cannot be considered finished till the water has been completely expelled under the rammers, and the surface left smooth and hard.

6. Care shall be taken to interfere as little as possible with the traffic, and the workmen shall be instructed to facilitate its passage by helping carts and carriages over the portions rendered partially impassable by their operations. No more surface shall be broken up, and no more metal laid in a single day, than can be consolidated in that day, and on closing work in the evening the surface shall be left smooth and fit for traffic and free from loose stones, rammers, and other obstructions. No heaps or loose material shall in any case be left at night on the road.

3. Maintenance.

1. The surface of the road shall always be maintained as near its original section as possible and kept smooth and free from holes and ruts.

2. Whenever holes or ruts appear, they shall at once be repaired by cutting out to the full depth the coat of metal in a rectangular form, extending everywhere beyond the limits of the defective patch, and filling in with new materials similar to that already laid down. These will then be consolidated with rammers till they form a hard solid cake, level with the rest of the road, as above described in the case of new work. Where it may be altogether impossible to procure water for consolidation in the hot weather, and it is essential to repair holes in a road, these must be dealt with as described omitting water; but in that case no gravel or other small stuff must be used. The holes must be filled with good hard and clean metal of rather large size, and rammed as well as may be possible.

3. The metal for these petty repairs shall be supplied by the contractor of the quality and description to be specified by the Executive Engineer, and the contractor shall be bound to keep up such constant supply of metal to be stored separately in such quantity and places as may be ordered by the Executive Engineer.

4. The earthen sides of the road shall be kept even, free from ruts and holes, and generally ranging in height with the surface of the metalled portion.

5. The side drains, shoulder or lead-off drains, and water channels, shall be kept free and open for the passage of water; but where great erosion may occur from excess of velocity, small obstructions must be introduced at intervals, so as sufficiently to check such velocity, or the number of shoulder drains may be increased.

6. Pavings and foundations, masonry, iron, and wood-work of all bridges and culverts to be examined every year, as also the beds of streams for some distance above and below the road, with a view to any preservative works that may be required, to prevent scour or accumulation of silt, being promptly carried out.

7. On no account and in no situation whatever shall metal or other material be stacked on the surface of the roadway intended for traffic.

8. When culverts are being repaired or rebuilt, only one-half shall be undertaken at one time, the other half being kept open for traffic. A clear space of nine feet in width shall always be left, more being given whenever practicable. If the repairs be of a character which indispensably requires the total closure of a culvert or bridge, a good and sufficient siding, with gradients nowhere greater than one in twenty and fairly hard surface, must invariably be made for the traffic, before the work under repair is closed to the public.

9. All gaps, foundation pits, &c., shall be fenced in with stout railings, their positions being marked at night by lanterns or watch-fires under charge of a watchman.

10. The roadside trees are to be tended and cared for, young trees being protected from injury with thorns or mud walls when necessary, and new ones planted in all gaps of existing avenues. All branches which interfere with the traffic will be cut down, but as a rule no such lopping should be allowed till the obstructing branch has been marked, and its removal has been authorised by the Executive Engineer. All unauthorised lopping must be strictly prohibited.

VIII.—LIMES, MORTARS, AND CEMENTS.

1. Lime.

1. To be burnt from such limestone or kunkur as the Executive Engineer may approve, and which shall be carefully freed from earth and impurities.

2. The process of burning shall be carried out near the site of the work (unless otherwise ordered) in such kilns and with such fuel as the Executive Engineer may direct.

3. In all cases the lime must be delivered at the site of the mortar mill quite fresh, *i.e.* within seven days of the date on which it was drawn fresh from the kiln; it must be entirely free from ashes, under-burnt particles, and other impurities, and be preserved perfectly dry till required.

4. It shall be slaked if so required in the presence of the Executive Engineer or his agents before being put into the mill, and all impurities

or pieces considered by them to be improperly or carelessly burnt shall be picked out, and removed at once from the work.

5. The portion not so removed shall be screened through such a sieve as the Executive Engineer may consider proper, and all stuff that will not pass through will be rejected unless otherwise ordered by the Executive Engineer.

6. Unless when the lime slakes freely and thoroughly, the quicklime is to be first ground dry for about ten revolutions of a mill of the usual pattern, and for mortar or cement the surki or sand is then to be added in the proper proportions with the water, after which the materials shall be ground for such length of time as the Executive Engineer may order. Care should be taken not to add more water than will bring the materials to the consistency of thick mud.

7. In wet foundations, and in all work which is likely to be exposed to the action of water within a month from the date of completion, either lime which is naturally hydraulic, or a cement made with fat limes and surki, or Portland or other cement in a perfectly fresh and active state, shall alone be used, as may be decided by the Executive Engineer.

8. Lime which has perished or mortar which has set shall on no account be used on the works, and shall be removed at once from the site.

2. Sand.

1. The sand and gravel used in mortar and concrete shall be highly silicious, coarse in texture, clean, sharp, and gritty to the touch. It shall be carefully freed by washing and screening from saltpetre, earth and other impurities, the locality of the supply having first been approved by the Executive Engineer.

2. Fine drift sand, or such as may be mixed with salt, should on no account be used.

3. Surki.

1. Surki should always be made of freshly but not necessarily overburnt bricks, or broken pottery, by grinding or pounding them.

2. The pounded brick must be perfectly clean, free from any admixture of foreign matter, and must be passed through a screen of 68 meshes to the inch before being mixed with the lime.

4. Mortar.

1. Shall be made of good fresh lime as in No. 1 and clean sand as in No. 2 mixed in the ratio of 1 lime to $1\frac{1}{2}$ or 2 of sand or in such other proportions as the Executive Engineer may direct.

2. The materials shall be well and thoroughly mixed, and ground in an edge mill or ghánee for 5 hours, or for such a length of time as the Executive Engineer may direct, care being taken not to add more water than will bring the materials to the consistence of thick mud.

3. Mortar shall be used as soon as possible after being mixed. It shall be kept damp in the shade or covered up till used, and if it has become set or hardened before being used, it shall be considered unfit for use and removed from the work, and no second mixing of it shall be allowed.

5. Pumice Mortar.

Shall be made as described for lime mortar, except that it shall have Aden pumice mixed with it in the proportion of 1 or ½ part of ground pumice to 1 of lime, or such other proportion as the Executive Engineer may direct. The pumice shall be dried and ground in a flour mill so fine that it will pass through a screen of 50 B. W. G. about 2,000 meshes to the inch; it is then to be added to the lime and ground and mixed. Pumice mortar must be used within 48 hours after it leaves the mill.

6. Mortar of Hydraulic Lime and Sand.

1. Lime is considered hydraulic when it sets within seven days under water, as tested by Vicat's Needle.

2. After burning, such lime shall be ground quick in a lime mill and passed through a sieve, with 150 meshes to the square inch; after which it should be mixed with the specified proportion of dry sand, and left under cover till wanted.

3. When required for use, small quantities of the mixture shall be mixed with sufficient water to make a thick paste, and shall be ground for such length of time as the Executive Engineer may order, as described under paragraph 6, specification for lime. The proportion of sand may be 1, 2, or 3 to 1 of lime, according to quality of the lime, but the exact proportions should be specified by the Executive Engineer.

7. Cement Mortar.

1. Shall, unless otherwise specified, be made by carefully mixing 1 part of good fresh Portland cement of approved quality with 1 part of good approved sand. Cement mortar shall be used within 3 hours after it leaves the mixing board or mill.

2. For concrete and rubble work the proportions of 1 part of Portland cement to 4 of river sand, both by measure, and for the finishing coat in plastering floors, 1 of cement to 2 of sand have been largely used on the Karáchi Harbour Works with excellent results. The foregoing refer to the bulk of cement as received in India, which was generally about 10 per cent. in excess of the bulk as despatched from England. See No. LXXXVIII. Roorkee Professional Papers, 2nd series.

8. Portland Cement.

1. This cement shall be obtained from a maker approved by the Executive Engineer.

2. It shall be fresh, uncaked, of light grey color, and well ground.

3. It shall begin to set in water within six hours after being mixed with water, and shall continue to harden afterwards.

4. It shall not crack or turn yellow while setting.

5. It shall be subject to tests (Grant's) as follows:—

(*a*) It shall weigh not less than 86 lb. or more than 100 lb. per cubic foot;

(*b*) It shall be ground sufficiently fine to pass through a sieve 2,000 meshes to the inch with not over 10 per cent. residue;

(*c*) When mixed neat with water and in 12 hours put under water, it shall on the seventh day after bear a tensile strain of 300 lb. per square inch.

IX.—CONCRETE.

1. General.

1. Unless otherwise specified, the rates entered in the schedule are to include the cost of mixing, lifting, throwing, placing, ramming, watering, wheeling planks, barrows, tools, and all appliances required to complete the concrete in position.

2. In all cases where concrete is laid under or exposed to the action of water, the lime must be hydraulic in itself, or be rendered hydraulic by the addition of surki.

3. Concrete may be of several descriptions; but the Executive Engineer should, in all cases, specify the quantities of each material to be used in different positions. As a general rule, the total proportion of lime or cement, surki (if used) and sand, should not be less than 60 per cent. by measure, nor the proportion of lime less than one-sixth of the broken stone, gravel or broken brick, the lime in each case being measured unslaked. Should Portland cement be used, the proportion of the cement to broken stone or gravel ought not to be less than one-tenth.

4. In all cases, when not otherwise specified, the lime or cement sand, and surki are first to be gauged with a small quantity of water into a stiff mortar. The other materials are to be separately wetted with as much water as is required to saturate them. The mortar is then to be mixed with them as specified in the next clause.

5. Unless otherwise directed, concrete may be mixed in the following manner; but it will be always preferable for the Executive Engineer to specify the process for incorporating the materials which he considers most suitable under the circumstances, and when large quantities have to be made it is of course desirable that, if possible, the material be mixed in a machine. A trench or narrow tank of convenient length is to be dug near the work and lined with bricks or planks. The mortar, previously mixed, and the broken stone, &c., previously wetted, are to be thrown in at one end of the tank in proper proportion: first one bucket of mortar, then three of stone, then

one of mortar, or as the case may be, as fast as the stuff is thrown in, it shall be drawn away to the other end of the tank by men with rakes or powrahs and thoroughly well mixed as it is moved along. From the other end the concrete shall be taken out and removed at once to its intended place.

6. Concrete is not to be thrown in from a height, or so as to cause the heavier materials to fall to the bottom. The consolidation is to be effected by ramming, each layer being about nine inches in depth (unless otherwise specified) and then left undisturbed.

7. When concrete is used in a coffer dam or trench full of water, it must not be shovelled in, as the lime will be washed out of it in its descent through the water, but lowered gently by means of a box or basket containing it, which will be overturned when it reaches the bottom so as to deposit the concrete.

8. No more concrete shall be mixed than can be laid in place the same day, and when Portland cement is used, it must only be mixed as it is laid, as the cement begins to set very quickly.

9. When concrete has to be set in soil containing saltpetre, sand shall be used instead of surki, in which case the lime must be naturally hydraulic.

10. Any material pronounced to be inferior or worthless shall be removed at the contractor's expense from the site of the work within 24 hours after written intimation to that effect has been given him by the Executive Engineer.

11. The concrete shall be laid in the work in layers not exceeding 9 inches in depth, and shall be well rammed with heavy wooden or iron rammers. The surface of each layer will be well watered and scored with lines before another is placed over it, so that the two may combine into one homogeneous whole. It will be well also to test the concrete from time to time by picking up small portions to make sure that a proper "set" has taken place.

12. If the lime does not fill all the spaces between the stones, and cream to the surface, the top of each layer is to be grouted with thin mortar before the next layer is laid.

X.—PISE' WORK.

1. General.

1. Mud pisé work shall be executed with good brick earth approved by the Executive Engineer. If dug fresh, no water will be required, but if the stuff jumps up under the rammers, it shall be sprinkled with water through the rose of a watering pot. Care is to be taken to add no more water than is absolutely necessary.

2. The boxes or mould boards to be of teak or other approved wood, each to be composed of two side frames 10 feet long and 2½ feet broad, made of 2 inch planks screwed to stout battens. These frames to be held together by four pairs of posts, each 3″ × 3″, connected at top and bottom about 2 inches from the edge of the boards by tie-bars of flat iron 1½″ × ¼″. The bars to have at each end half-inch holes, 3 inches

apart, punched in them, to receive pins to prevent the posts slipping off. Wedges of hard wood with longitudinal slots to be interposed between the pins and the posts to enable the boards to be tightened up to the required gauge. After the boxes are fixed in position, they are to be secured by ropes passing over them and made fast to pegs on either sides. The boxes must be set truly vertical and level.

3. The earth on being dug out is to be passed through a screen with half-inch meshes, and thrown into the boxes in even layers 6 inches in depth. The earth is to be first beaten down with a V-shaped rammer, then finished with a flat one. The sides are to be consolidated with a rammer shaped to fit close up against the boards. The men are not to be allowed to keep time in ramming.

4. The boxes filled during the day are to be left all night, and in the morning taken off and set to the proper position for the next layer. The top tie-bars will be left in position, forming the bottom tie-bars for the next course. As the ties are 2 inches from the edge of the boards, the boxes in position for the upper layer will overlap the lower one by 4 inches, and will thus give a good hold. The lower tie-bars will be withdrawn (unless required to support scaffolding) by passing a pin through the hole next the wall and using a crowbar as a lever. If the lower course from any cause has been left too dry, the surface must be moistened and slightly raked up before the new course is begun.

2. Mud Plaster.

1. For mud plaster none but well tempered clay, or brick earth free from vegetable mould, gravel, or roots, shall be used. The clay is to be sifted fine and thrown into a pit with chopped straw and cow-dung in such proportions as may be ordered. It is then to be well mixed and flooded with water and left for a week or two, after which it is to be floated on in thin coats, any extra thickness required being given by increasing the number of coats, not the thickness of each.

XI.—BRICK AND TILE MAKING.

1. The earth for bricks must be carefully selected, good firm loam. All gravel, coarse sand, kunker, and roots of grass or plants shall be thoroughly eliminated by washing or other means ; but two or three sorts of clay can often be found which, when mixed, make better brick than loam ; the Executive Engineer must, however, in all cases decide.

2. The earth as selected and approved will be repeatedly turned over and thoroughly tempered. When practicable, it should be dug up before the rains set in and left to weather for a few months; but when this cannot be done, it must be thoroughly watered, turned over for at least 48 hours before use, and tempered until stiff enough for moulding. The tempering should be done in a pug mill, or by treading with the feet. The earth thus treated should be homogeneous throughout and sufficiently stiff for moulding.

3. The clay must not be taken from localities where salt water is found, and any clay containing the slightest trace of salt will be rejected for brick-making purposes.

4. In moulding, the stuff will be dashed firmly into the moulds which should be kept well sprinkled with clean, sharp sand. The clay must be used as dry as possible, and proper moulding blocks and pallet boards employed in all cases; but a brick table is better than blocks and should, where practicable, be employed. The mould requires washing for every 4 or 5 bricks moulded. Strikes or floats should also be used.

5. The bricks must be turned out with clean sharp edges, well and squarely shaped; and after moulding must be carefully handled in stacking to prevent their becoming distorted. Iron brick moulds ($\frac{1}{4}$ inch plate) with the top and bottom steeled, are the only moulds that keep their shape, and with a few repairs, turn out 500,000 bricks.

6. The bricks, if not otherwise specified, to be $9'' \times 4\frac{1}{2}'' \times 2\frac{1}{2}''$. The necessary allowance for shrinkage in drying and burning must be determined by actual experiment for each brick-yard. The chief cause of cracking in bricks being caused by exposure to wind, protection against this should be given by mat screens or sheds if necesary whilst drying.

7. All fuel for brick burning should be as dry as possible, and used when comparatively fresh. Tamarind or bábul is the best wood to use in burning.

8. The earth for tiles may be similar to that above specified for bricks, but must be even more carefully prepared, and better tempered.

9. All tiles must be thoroughly well burnt throughout, of regular shape and uniform size, sharp, even, and free from twists, bends or flaws. They must be of a deep red colour, and ring clearly when struck.

XII.—BRICK WORK.

1. Brick in Chunam.

1. Brick work will be considered as being of three classes. The *first* class to be constructed with table moulded bricks free from defects; the *second* class with ground made bricks specially made for the work, though otherwise of first class quality; the *third* class with bricks purchased in the market, sound and well burnt. In all cases the bricks must be free from defects and approved by the Executive Engineer.

2. In no case shall bricks of different dimensions be used in the same work, except when specially permitted by the Executive Engineer.

3. All the best shaped bricks and those most uniform in color shall be reserved for face work.

4. The mortar to be used shall be that specified and approved, and subject to the conditions laid down in Section VIII.

5. No four courses of work, with three joints, shall exceed in thickness when built, 1 inch more than the same bricks piled one upon another without mortar.

6. The bricks shall be well saturated with water, unless when the mortar is of fat lime and sand, in which case soaking is detrimental; and every one or two bricklayers supplied with a tub or trough of water in which the bricks shall be kept before using.

7. All unfinished portions of masonry, laid in surki or hydraulic mortar or cement, shall be left flooded with about 1 inch in depth of water standing on it at the end of a day's work.

8. No bats shall be permitted to be used, unless where absolutely required for obtaining the dimensions of the different courses, or for obtaining the specified bond.

9. The bricks shall be thoroughly bedded and flushed with mortar, and shall be grouted full at every fourth course.

10. The bond used shall be English, or such other as may be specified, and shall be carried throughout the wall. At all angles forming the junction of any two walls, the bricks shall, at each alternate course, be carried into each of the respective walls so as thoroughly to unite the work.

11. The work must be finished in all facework with a neat drawn joint, and pointed; when the facework has to be plastered, the joints shall be well raked out before any plaster is laid on; should the plaster, from want of proper joint raking, detach and fall off from the brickwork, the contractor shall be liable to strip off the plaster bodily and do the work properly at his own expense.

12. Scaffolding must be double, that is, it must have two sets of upright supporters. Care must be taken, in leaving out a brick to allow the end of the scaffolding pole on the inner side to rest on the wall, that such brick is always a header, and that not more than one header for each pole is ever left out. By this means the bond of the wall can easily be made complete and perfect as the scaffolding is being removed. To insure the safety of the workmen, all scaffoldings must be approved by the Executive Engineer.

13. The walls of all structures shall be carried up regularly in all cases when the nature of the work will admit of it, not leaving any part 3 feet lower than another.

14. When circumstances render it necessary to carry on the same section of a building in uneven courses, the breaks shall be raked back, so as to maintain a uniform and effectual bond.

15. In all cases, returns, buttresses, counterforts, &c., are to be built up course by course, well and carefully bonded into their main walls. These are never to be joggled on afterwards. (See also paragraph 10).

16. In all arches, the voussoir joints shall be truly perpendicular to the tangent of the curve at all points.

17. In setting the bricks in arches, they are to be well pressed into their beds so as to squeeze the mortar out and leave the joint thin.

18. All arches to be turned on centerings approved of by the Executive Engineer, and which up to 16 feet will be included in the rates. Sand boxes being invariably used for lowering arches over 23 feet span; such boxes will be furnished by the Executive Engineer on loan to the contractor unless otherwise specially arranged for.

19. The bricks for skewbacks shall be all properly cut, and no remedying of defects in this particular, by extravagant use of mortar,

will on any account be allowed, nor will patching up by chips &c. be permitted.

20. The bricks at the spandril walls shall be cut so as to fit the curvature of the arch. Round pillars will be built with quadrant shaped bricks, and when they are of considerable height, flat circular discs of stone, of the same diameter as the pillar, and about 3 inches thick, shall be introduced at every 4 or 6 feet as bond stones; the cost of such discs is included in the rate for brickwork.

21. Door and window openings shall have flat or relieving arches across them; a flat arch shall have a camber or rise of 3 to 4 inches.

22. String courses, cornices, and mouldings will be set straight and true, with as fine joints as possible.

23. The ends of all girders should rest in recesses, having space for the free circulation of air round the timber; no deductions from the contents of the wall will be made in order to compensate for the additional trouble in forming such.

24. All plain brickwork in walls, arches, square columns, brick on edge, and flat floors, and under flagging in floors and roofs, will be measured net, whether the bricks be moulded or not, according to class.

25. All cornices, corbels, brackets, strings, beads, ogees, circular and polygonal columns, mouldings, &c., will be measured square over the greatest depth and projection for the whole feature.

26. No deductions will be made for flues left in the masonry for fire, ventilation, or drainage purposes.

27. No extra price will be paid for wooden bricks built into masonry, the wooden bricks themselves are to be supplied without charge.

28. The rate for each description of work includes scaffolding, tools, and plant of every description.

29. All building materials brought to site of the work to be properly stacked at once, for facility of inspection and measurement.

30. On completion of a work, all bricks and other rubbish to be removed, unsightly holes or pits levelled up, and the whole surroundings of the work left clean and neat, before the accounts are closed.

2. Brick in Mud.

1. The mud mortar joints shall not be more than half an inch thick.

2. The mortar shall consist of well tempered clay, having neither too much nor too little sand in its composition.

3. The rules given for "brick in chunam" will apply generally.

3. Sun-dried Brick in Mud.

1. Shall be constructed under the same specification as the above given for "brick in mud," with the exception that the bricks will not be burnt.

2. The bricks to be well moulded of tempered clay and well dried before using.

XIII.—STONE MASONRY.

1. General.

1. The stone to be used will be that taken from the quarries indicated by the Executive Engineer in his specification, or such as may be ordered on the spot, at the rates agreed to in the contract bonds. It will be hard, durable, and tough, and each stone must be laid when in the work on its natural quarry bed.

2. The mortar to be used will be that specified by the Executive Engineer, and subject to the conditions laid down in Section VIII.

3. The work is to be kept wet while in progress till the lime is properly set. On Sundays and other holidays the top of all unfinished masonry is to be kept flooded, and labourers are to be employed for the purpose. Watering is to be done carefully so as not to wash the lime out of the joints.

4. All stone masonry built with surki, or hydraulic mortar, or cement, shall be kept well watered in the same manner as is laid down for brickwork.

5. Scaffolding will be double, as described for brickwork; but the ends of poles need not in this case be placed in the position of a header stone.

6. All mouldings to be worked to templates cut out of sheet zinc.

7. All copings to be dowelled or cramped, if so ordered or specified by the Executive Engineer, and the courses of pillars, skew backs, and similar work to be joggled to the stone below.

8. Dowels and cramps to be of the hardest and toughest stone procurable, or of copper, and also set in pure lime.

9. Iron cramps are not to be used.

10. In all battering, retaining, and breast walls, the beds of the stones and the plane of the courses to be at right angles to the batter.

11. Large flat stones are to be laid in all cases under the ends of girders, roof trusses, &c.; their dimensions being invariably specified by the Executive Engineer.

12. Should the mortar perish, that is, become dry, white, or powdery, through neglect of watering, the work will be pulled down and rebuilt at the contractor's expense, or, should the contractor fail to water the work to the satisfaction of the Officer in charge of the work, the latter may supply the requisite men to water the work properly, and charge the cost to the contractor.

13. Where practicable, the whole of the masonry in any structure will be carried up at one uniform level throughout, but where breaks are unavoidable, the join will be made in good long steps, so as to prevent cracks arising between the new and old work. All junctions of walls to be formed at the time the walls are being built, and cross walls to be carefully bonded into the main walls.

2. Ashlar.

1. To consist of stones hewn to such shapes and sizes as may be specified, or shown in the drawings, or required for the due execution of the work according to design.

2. Every stone shall be dressed with the punch tool on all beds, joints, and faces; full, true, and out of winding, if the surfaces are plane; or to uniform curves or twists if so required by the design. Those faces exposed to view shall have a chisel draft of 1½ inches round all the edges, and be fine punched between the drafts. All visible edges shall be quite free from unsightly chippings.

3. The stones shall be set in the work-flush in fine mortar, the beds or joints being in no instance thicker than ¼ of an inch or not thinner than ⅛ of an inch. No "pinnings" of any description will be allowed; and hollow bedding, and flushed joints, are to be carefully avoided. Each stone will be struck with a maul when laid, to bring it to a solid bearing both as to bed and joint.

3. Ashlar Walling.

1. The stones shall be laid in regular courses of a depth not less than 12 inches, unless otherwise ordered.

2. No stone shall be less in height than the depth of the course in which it is, or in breadth less than its height, or in length less than twice its breadth.

3. The face stones shall be laid header and stretcher alternately, or one header to two stretchers, as may be ordered by the Executive Engineer. The headers shall be arranged to come as nearly as possible in the middle of the stretchers of the adjacent course; and the stones shall bond, overlap, or break joint on the face at least half the depth of the course they are in; and in the hearting the bond shall be carefully maintained. In walls less than 3 feet thick, one-half the headers shall run through the whole thickness of the wall.

4. The course lines and bed planes shall be true and level throughout, and the side joints shall be vertical, unless otherwise specified or ordered or designed.

4. Ashlar Facing.

1. No course to be less than 8 inches thick. One-third of the entire length of each course to be headers. No stone to be less than 1′ 6″ long; and when the thickness of the course does not exceed 10 inches, the stones must not be less than 15 inches on the bed. Where the thickness of the ashlar courses exceeds 10 inches, the breadth of the beds will not be less than one-third more than the thickness of the course.

2. No header to be of less length than 18 inches in excess of the breadth of the course of ashlar to which it belongs. The beds and joints of all ashlar stones to be dressed perfectly true, square, and full.

3. The thickness of ashlar in plain walling to be as noted in the drawings, and measured one-third more to compensate for the extra length of headers.

4. This work may be either rock faced with a chisel draft round the edges, or chamfered; or plain dressed; but one rate for all will be entered.

5. Ashlar Arching.

1. The arch stones to be in all cases of the entire thickness of the arch, and to be carefully and accurately wrought, giving the proper radiating joints.

2. The intrados to be fair broached; the beds and joints fairly wrought and left full; the last or keying course is to be accurately fitted and driven into its place with heavy wooden beaters; all horizontal joints across the intrados to have a $\frac{3}{4}$ inch chamfer to prevent the arrises of the voussoirs chipping off under the pressure.

3. The face stones of ashlar arches may be tooled or rock faced, with or without a chamfer, as may be directed.

4. Exact uniformity will be required in the thickness of each course of arch stones; and in the oblique arches great care is to be taken to dress the beds to the wind required by the obliquity of the arch.

5. The rate to include cost of centering up to 6 feet span. No centerings to be struck without the written permission of the Executive Engineer.

6. Ordinary Stone or Rubble Work.

1. In ordinary stone work no stone will be less than 5 inches thick, nor will it contain less than $\frac{1}{3}$rd of a cubic foot. The largest stones will be selected for the face; they will be set flush in mortar, headers and stretchers alternately, (at least one header to three stretchers) the former projecting at least 5 inches beyond the latter. Every sixth header in walls up to 2 feet thickness will be a through stone, and in wall beyond that thickness $2\frac{1}{2}$ feet long. The interior will be filled in with good stones, set as close as possible, thoroughly bedded and flushed in mortar, the interstices being closely packed with sound stone chips. In the walls of buildings where coursed rubble is specified, the stone work will be brought to a level bed at every 18 inches of height, grouted, and made perfectly solid; but in retaining or other walls subject to transverse strains, no such coursing shall be allowed.

2. In house walling, a layer of flat stones, extending the whole breadth of the wall, will be laid at intervals of 6 feet in height, especially at the floor line and under all girders and roof trusses.

3. In arches, the faces of the stones will be dressed truly radiating from the center, and the bed joints will be properly summered; the ends of the face stones will also be dressed.

4. All quoins and jambs will be hammer dressed on the beds and face, so as to sit level and show a clean arris. Good square stones should be selected for them.

5. Rubble stone may be laid in mud, when the same directions for bond and construction as above will be attended to. The upper 12 inches of such walls should, however, be laid in mortar, and if not roofed over should have a proper coping of stone in mortar or other sound material.

7. Coursed Stone Work.

1. In coursed stone work, the face stones will be set in regular courses uniform in thickness throughout; no course to be less than 6 inches thick, and as much thicker as the quarry will permit. No stone to be less than 9 inches broad on the bed, or to be greater in thickness than in breadth of bed. The backs to be left rough as quarried, the end joints being hammer-dressed, square with the face, for a width of not less than 6 inches back from the face.

2. Vertical joints to have at least 3 inches lap over the joint below; the courses to be arranged with as much uniformity as possible, the narrower being kept towards the top of the structure, and the wider ones towards the bottom.

3. The bond to be used as specified by the Executive Engineer.

4. The headers shall always project at least 7 inches beyond the stretchers, and at intervals of 6 feet or thereabouts; they shall run right through the wall where the thickness does not exceed $2\frac{1}{2}$ feet, or $2\frac{1}{2}$ feet into it when it exceeds that thickness. The through stones in any one course will come halfway between those in the course below.

5. The backing will be similar in quality to that specified for ordinary stone or rubble work.

6. The arches, quoins, jambs, &c., shall be as specified for such work under "Ordinary Stone or Rubble Work."

8. Dressed Stone.

1. Dressed stone will only occasionally be required in steps, mouldings, and cornices of buildings, or in the imposts, string courses, and copings of bridges, and culverts.

2. All beds and joints will be worked true and square, and no hollow beds will be allowed.

3. The upper surface of copings, and all weather tables, and the face and tread of stone steps, will be neatly tooled; all key stones and arch voussoirs will be carefully and accurately summered.

9. Stone Flagging.

1. Stone flagging in floors, and over roof beams, to be laid with an even surface and close joints chamfered off to the back, but the joints shall in no case be less than $\frac{1}{2}$ inch thick from the face, and joints not wider than $\frac{1}{8}$ of an inch thick. The exposed face to be fair dressed. In minor buildings, the stone may be quarry scabbled only, and the joint left more open, but nowhere more than $\frac{3}{8}$ths of an inch wide.

2. In floors, the flags are to be laid on a bed of concrete not less than 6 inches deep, carefully levelled. In roofs, the joints between adjacent slabs must be exactly over the joist which supports them.

3. Stone covers to flat topped culverts will be of good square blocks, never less than 4 inches in thickness where the span is 2½ feet, or less than 1¼ inches for each foot of span where over three inches in thickness, to every foot of void spanned by them; the length in no case to be less than 2 feet in excess of the span. The sides will be dressed square with the hammer, so that they may fit closely together without interstices. Where necessary, they will have a layer of brick-work or concrete set over them, so as to keep the earth from falling through and causing holes in the metalled surface.

10. Dry Rubble Works.

1. To be of angular, flat bedded, well shaped stones, laid in courses, breaking joint, exactly similar to "coursed stone work" without the mortar. The work to be brought up with a batter of not less than 1 in 12.

11. Dry Stone Pitching.

1. To consist of large stones, regular in shape as far as possible, and no stone to contain less than ½ a cubic foot. The stones to be laid regularly and evenly, breaking joint as much as possible, and to be beaten down with heavy rammers so as to imbed them into the earth. The interstices to be closely and firmly packed with sound stone chips well driven in with a hammer. Loose stones in the packing on no account to be allowed. The surface of the entire pitching when completed to be flat and even.

12. Dry Stone Revetment.

1. The stones to be perfectly sound, as regular in shape as possible, and their lengths about equal to the thickness of the required revetment without the backing.

2. The sides of the bank to be trimmed to the required slope, and profiles put up by means of lime and pegs at the required intervals, to insure regular straight work and a uniform slope throughout.

3. The stones to be laid closely in position and firmly bedded, the length being made perpendicular to the face of the revetment.

4. The backing may consist of smaller stones closely packed, or of gravel and clay in layers of 6 inches, carried up simultaneously with the revetment, and well watered and rammed.

13. Rough-Stone Ghat Revetment.

1. The stone collected to be perfectly hard and as rectangular as can be found in the locality; to be collected to the full extent required, and to be approved and passed before any part of the building is put in hand.

2. For revetments up to 6 feet high no stone (except spalls) is to be less than 1½ feet in length, and for revetments above 6 feet in height, no stone (except spalls) to be less than 2 feet in length, for that portion of the wall below the top 6 feet for which 1½ feet stones are allowed.

3. The revetment to batter at 1 in 4 on the face and to be built in plumb steps at the back. Each step or offset to be 6 inches, and the foundation to be carried down to perfectly firm and solid soil.

4. The first course of stones, specially selected for flatness on one side, will be laid carefully in the bottom of the foundation trench, close together, side by side as headers, and the interstices carefully wedged up and packed with spalls. A jungle slab, not less than 3 feet in length, and not less than 6 inches thick, to be introduced in every 10 feet in this course, and in every course throughout the work. When this slab only reaches halfway through the course, two slabs to be laid abutting end to end, so as to bind face and rear together. Above the first course work will then proceed with front and rear facings of alternate headers and stretchers. All vertical joints to break with those of the course immediately below, and base course and courses above to be laid perpendicular to the front batter. Every stone to be laid flatwise, not on edge, and in close contact with its neighbours. No projecting stones to be allowed.

5. The work to be brought up independently of the backing for a steady height of 3 feet above the latter, and the wedging of the rear face of work to be carefully seen to. The whole of the face to be also well wedged up at the chose of the work.

6. The earth-filling behind revetment to be brought up in 12-inch layers at a time and thoroughly consolidated dry with heavy tampers. The space contained between rear face of retaining wall and a vertical line from the corner of lowest offset, to be filled in with small stones of chips well hand-packed.

XIV.—PLASTER WORK.

1. Rough Casting.

1. The plaster will be composed of the ingredients laid down for mortar in the specification of the Executive Engineer, but to insure no unslaked lime remaining, must have been mixed a sufficient time during which it must be constantly mixed, stirred up, and turned over. To this will be added such quantities of cow hair, chopped hemp, coarse sugar (jaggery), shell lime, white of eggs, linseed oil, &c., as the Executive Engineer may specify.

2. Previous to the application of the plaster the joints of the brick-work or masonry must have been raked out to a depth of at least half an inch, after which the wall must be cleaned down and kept thoroughly damp for two days before the plastering is commenced.

3. The plaster shall be laid on (after the wall has been thoroughly wetted with water) with somewhat more than the required thickness and levelled with a flat wooden rule, when it should be beaten till no impression is made on the surface.

4. When two or three coats are ordered, the first must be allowed to set, but not to become dry, before the second is laid, the surface being left rough and freely scored all over with the edge of the trowel to prepare it for the next coat.

5. The last coat is to be smoothed with a wooden rubber and polished off with a trowel. During this operation it is to be sprinkled occasionally with a little pure lime and water.

6. The thickness of each coat, and the number of coats, to be as directed by the Executive Engineer. When not otherwise specified, the first coat will be half an inch thick, or so much more only as will bring up the inequalities of the masonry to a uniform surface.

7. All mouldings will be worked true to a template and drawn neat, clean, and level.

8. Fine lime plaster (to be used in finishing off terraced roofs, floors, cornices, and mouldings) will be composed of equal parts of the best stone lime and sand (or surki). It will be laid on as directed above for ordinary plaster, and will be finished off with a fine coat of pure lime well rubbed in with a float.

9. For very fine work in buildings, a little powdered soap stone will be used during the process of finishing, to increase the whiteness and polish of the plaster on the walls.

10. Before replastering a wall or a portion of it, the decayed and loose parts shall be stripped off, the joints raked out, and the surface of the wall well watered, before the fresh plaster is laid on.

11. Fine mortar may be prepared by grinding the mortar in a hand-mill or upon a stone slab, as is the native practice.

12. Plaster will be measured on the length and height of the walls, without deduction on account of openings or additions on account of returns and soffits, the latter being held to be the equivalent of the former.

2. Cement Plaster.

1. The walls to be prepared as above.

2. "Render" with a mortar of equal parts of Portland cement and fine sand 1 inch thick, unless otherwise specified, and roughen but do not beat.

3. Float with a thin coat of pure Portland cement and smooth off well.

XV.—FOUNDATIONS.

1. Foundation trenches shall be taken out to the exact width of the lowest step of the footings; the sides will be left plumb where the nature of the soil admits of it; but they must be sloped down, or shored up carefully where the soil appears treacherous or likely to fall in.

2. The foundations of all important bridges and viaducts, or other large works, must be approved and passed by the Executive Engineer before constructive works are commenced; those of smaller bridges, culverts, or ordinary buildings may be passed by the Assistant Engineer or by an experienced subordinate.

3. All foundation pits must be taken down to firm hard soil, the incompressible quality of which, when subject to moisture, and probable thickness should be ascertained before the foundations are passed.

4. Where practicable, the foundations will be taken out at the same level throughout. If pit-holes occur, they will either be dug out square and filled with concrete, or, if too deep for this mode of treatment, will be carefully arched over and well filled and rammed.

5. When old walls and foundations are met with, they shall be dug out to the level of the trenches. Old wells will be strongly domed over after being first cleared of all loose material, and subsequently well filled and rammed if they come within the site a building, or within the seat of the embankments.

6. The bottom of foundation pits will be dressed level in all directions, and, before any concrete or masonry is put in, will be well watered and thoroughly rammed. No filling will be allowed in thus bringing the foundation soles to proper level throughout.

7. The contractor shall, at his own expense and without extra charge, make provision for all shoring, pumping, dredging, baling out or draining; and the excavations shall be kept free of water while the masonry is in progress in such manner as the Executive Engineer may direct.

8. All foundation pits must be refilled to the original surface of the ground with approved material, well watered and rammed.

9. No material excavated from foundation trenches, of whatever kind it may be, is to be placed nearer than 4 feet from the outer edges of the excavation.

10. The rate paid will include lifting and removing soil to any distance within 50 feet of the center of excavation. If the soil be removed to a greater distance than 50 feet, the extra schedule rate for increased lead of earthwork will be allowed. The rate will also include filling in again round the foundation walls, ramming, and securing in the ordinary manner.

11. In filling foundation pits, the earth shall be set in regular layers not exceeding 9 inches in thickness, and shall be well watered and rammed.

12. Near large towns and in all frequented places, foundation pits, wells under construction, and similar excavations shall be strongly fenced, and, where necessary, shall be marked at night by lanterns or watchfires under charge of watchmen.

13. Difficult foundations, involving pumping arrangements, coffer dams, &c., when required, will form the subject of a special specification, to be drawn up with distinct reference to the requirements of each particular case.

XVI.—WELL SINKING.

1. For Supply of Water.

1. The rates, when the work is executed by contract, to include all necessary plant and tools in any way required for the execution of the work.

2. Wells to be fenced round during execution of the work; and, if near a public thoroughfare, lights and a watchman to be provided by the contractor without extra charge.

3. In wells lined with brick-work or stone steinings, the excavation will be carried down below the permanent spring level of water before the curb is laid and steining built up. No commencement of such steining shall be made without the express written permission of the Executive Engineer.

4. The steining will be sunk to such further depth as the Executive Engineer may direct. Unwatering to be a subject of special agreement.

5. If the steining split during the sinking, or within six months after completion, and, in the opinion of the Executive Engineer be unsound, the contractor shall be bound to dismantle the whole or part according to circumstances and reconstruct it without charge; and if the falling in of the sides of the excavation from insufficient shoring or any other cause due to negligence of the contractor render it necessary in the opinion of the Executive Engineer, the contractor shall be bound to sink an entirely new well without charge.

6. Excavating the shaft to spring level will be paid for by the thousand cubic feet excavated, at such varying rates according to the depth as may be specially agreed on.

7. Curbs and other timbering, with the iron work, will be paid for under those heads according to class.

8. The brick-work or stone masonry will be paid for according to class under that head, or the well of given diameter may simply be paid for per yard of depth.

9. Small wells may be lined with burnt earthen rings of not less than 2 inches thickness and 12 inches depth; to be paid for by rates including lowering, fitting, and fixing in position, as may be specially agreed on.

10. Old wells cleaned out, whether lined or not, will be paid for as excavation, with an additional rate for working under water. (See also paragraph 4.)

11. It occasionally happens that the sinking of steining cannot progress on account of the interposition of a bed of kunker or hard soil, below which a sufficient supply of water would be found. In this case it may be necessary to "under-pin" the curb. But if the soil is very firm or the curb rest on a bed of block kunker, it will be in

the option of the Executive Engineer not to carry the steining through, but merely to pierce the bed with a shaft of less diameter than the diameter of the well. These and other exceptional matters will be subjects of special agreement according to the circumstances.

12. Curbs are to be made of babul, tamarind, or other wood, approved by the Executive Engineer as lasting under water.

13. Wooden curbs, for wells of 6 feet diameter and under, will be made of two thicknesses of wood, and for wells above that size of three thicknesses, strongly dovetailed and dowelled together, and secured by iron bolts, as ordered by the Executive Engineer. When the rings cannot be made of one piece across the width, the concentric rings shall break joint; the upper and lower courses to be alternately one-third and two-thirds of the whole width.

14. When ordered by the Executive Engineer, the curb will be secured to the masonry by iron holding-down bolts, over the upper end of which an iron bond plate shall be passed and secured by nuts.

15. In under-sinking wells, great care shall be taken to keep the steining truly vertical; for this purpose three plumb lines shall be kept suspended round the inside of the steining.

16. The space around the steining shall be filled in with dry rubbish, clean and free from objectionable matter, and well rammed.

2. For Foundations.

1. The specification given above will apply to sinking wells for foundations, with the following additions:—

(*a.*) A plate of $\frac{3}{8}$ of an inch sheet iron to be put on round the outside of the curb, projecting 2 inches above the top, to hold the brick-work, and 2 inches below to form a cutting edge.

(*b.*) The whole of the masonry to be flat joint, pointed on the inside, and carefully plastered on the outside, to reduce the friction in sinking.

XVII.—ROOFING.

1. Pucka Terracing.

1. Pucka terracing to roofs will consist of a course of thoroughly burnt terrace bricks (6 inches × 3 inches × 1 inch) laid diagonally over the joists. When this has set, a layer of brick concrete 3 inches thick will be laid and well beaten with wooden hand beaters, the whole being kept wet by sprinkling lime water.

2. When the concrete has hardened, three courses of flat tiles will be laid in surki or hydraulic mortar or cement, the tiles being well soaked, so as to break joint.

3. Three coats of plaster to be then applied and carefully rubbed to a polished surface, or, over the first rough coat of plaster, a mixture of hot tar and sand to be applied with trowels and smoothened with a smoothing board. The surface of the tar to be washed when set with two coats of good whitewash.

2. Arched Terracing.

1. Will consist of rolled iron beams, painted with one coat of red lead, and placed from 4 to 7 feet apart, resting on stone slabs. The beams to be laterally tied with flat iron bars $1\frac{1}{2}$ inches $\times$ $\frac{3}{8}$ inch, riveted to the upper flanges, and the ends of the tie bars to be riveted to an angle iron embedded in the wall.

2. The walls to be then built up to the level of the top of the beams, leaving a space of about 6 inches for the arch to be built into the wall. The centerings for turning the arches may consist of segments of mango or any other country wood about 3 inches in thickness, and should be placed about 5 feet apart, with bamboo or country wood battens nailed to them about an inch apart. The battens should be covered with bamboo matting, over which a layer of clay is laid and worked smooth and true with wooden templets and to the required radius of the intrados of the arch. On this the arch is built.

3. The arches to be turned with the usual terrace bricks. The thickness to be about 6 inches and the rise from $\frac{1}{8}$ to $\frac{1}{10}$ the span. About three or four days after completion of arches, the spandrils to be filled in and arches covered with concrete to a level of about 3 inches above the top of the rolled beams.

4. The concrete to be beaten down with wooden beaters as specified for pucka terracing, and finished off as above with tiles and plaster, or with tar and sand, or joists and boards, flagging, asphalte, or any other way that may be desired.

3. Double Tiled Roofing.

1. To consist of a double layer of well burnt, semicylindrical tiles of the usual size, laid on sawn teak battens, $2'' \times \frac{1}{2}$, placed 2 inches central distance apart. Tiles to be soaked for 12 hours before use in water mixed with cowdung.

2. Ridges and hips to be constructed of ridge tiles, and hips, ridges, and eaves to be set in mortar.

3. All wood work used in trusses, purlins, rafters, &c., to be thoroughly seasoned, neatly planed, varnished or painted, or oiled only, and in other respects as specified for woodwork in general specification No. XXIV.

4. Trusses to be properly framed and placed from 8 to 10 feet apart: common rafters to be in continuous lengths from ridge to eave (wherever possible) and to be fixed at central distances of 15 to 18

inches apart. Purlins to be scarfed, or overlapped, on the principal rafters of the truss on which they rest, and secured in position by purlin blocks.

5. All iron straps, bolts, &c., to be of good workmanship and carried out in accordance with general specification No. XIX.

4. Mangalore Tiling.

1. Will consist of thoroughly burnt Mangalore (sometimes called "Mission") tiles, laid fair and square and properly fitting with the catches resting fully against battens, 1 inch × 1¾ inches, nailed 12½ inches from center to center to the upper surface of rafters and exactly at right angles to their direction. Care to be taken that each course is laid perfectly parallel to the rafters.

2. Below the channel along edge of the lowest or eaves row of tiles a batten of extra thickness to be used to make the slope even and continuous from edge to eaves.

3. The edge and hip tiles will be set in the best mortar, and where high winds prevail, the ends of the tiles of the eaves course shall be nailed with iron nails, or secured by wire to the batten above the eaves board.

4. In excessively wet localities it is advantageous to well coat with tar the beds or channels of the Mangalore tiles.

5. Thatched Roofing.

1. The bamboo frames upon which the thatching rests to consist of well seasoned and sound bamboos laid longitudinally 9 inches apart, the butt ends being reversed alternately, crossed by half bamboos laid about 3 inches apart and tied to them, the whole being firmly and securely lashed to the rafters below.

2. The grass when tied into bundles for thatching shall not show a length of less than 30 inches. Before being tied, the grass to be well sprinkled with water and cleaned of the leafy portions and dried by being lightly beaten with a light stick.

3. Thatch 9 inches in thickness will be laid in 3 inch layers, each course securely tied to the framing of the roof, the fastenings being at no greater distance apart from each other than 9 inches.

4. The eave bundles to be of the full thickness of the grass coating, evenly and tightly laid, cut off squarely and neatly, and perfectly straight. Ridges and hips to be protected with bamboo framework lapping 2 feet on either side.

5. The roof when finished shall be even, without undulation; the racks parallel to each other.

6. Corrugated Iron Roofing.

1. Will consist of sound, galvanised, corrugated iron, of 16, 18, or 20 B.W.G. or such other gauge as may be ordered by the Executive Engineer. The sheets will be laid with laps of 6 inches at the ends, and of two corrugations at the sides, and vertical laps shall be turned away from the rainy quarter.

2. The holes for rivets to be drilled out (not punched) from the inside towards the outside, at a distance of about 9 inches apart on the sides and every second corrugation on the ends. Holes to be punched in the ridges, not in the gutters of the corrugations.

3. The sheets when so fastened with the best galvanised iron rivets and lead washers to be set carefully on the purlins and fastened to them by approved fasteners, that is by galvanised iron screws and washers, or by bolts, or hooked bolts, as may be ordered by the Executive Engineer. Such bolts or screws will be placed at the corners when the four sheets overlap each other, and all bolts, screws, and rivets will be set in white lead.

4. Ridges and hips will be covered with galvanised iron or zinc capping, 20 B. W. G., having a foot lap on each side and securely fastened down so as to prevent the rain driving under it.

5. When the roofing is used in an open shed or verandah and without teak planking to the underside of the purlins, the plates must be fastened down by continuous lengths of wrought or bar iron, 2 inches × ¼ inch, bolted through the purlins. When the bolts pass through these wind-ties, slot holes will be cut to allow for contraction and expansion.

7. Continuous Sheet-iron Roofing Galvanised.

1. Will be laid over planking or on wooden or iron laths on purlins. The whole of the rivets, screws, bolts, and other fastenings must be galvanised. The continuous sheets after being cut to lengths to suit the roof will be securely riveted together along the edges, the overlap being 6 inches.

2. All rivets must be tightened and drawn closely home, and the heads spread evenly and equally, and properly hammered and set down all round.

3. The sheeting will be then securely fastened to the planking or purlins by proper fasteners, hook iron bolts being used when the purlins are of angle iron. Where a bolt-hole is made through the sheeting for fastening it down, a lead washer 2 inches square and ⅛ inch thick will be laid over the sheeting and under the bolt head to prevent the sheet tearing, or a washer made of hemp or jute soaked in boiled linseed-oil and covered with red lead putty.

8. Zinc Roofing.

1. Will consist of 18, 19, and 20 B. W. G., "Italian corrugation," screwed to wooden rolls with patent embossed holes and screws, the screws not to penetrate both sheets at the lap.

2. The horizontal joints to be made by folding laps secured by clips 2 inches wide placed apart. Care to be taken to give every facility to the zinc for expansion and contraction.

9. Shingle Roofing.

1. To consist of sound unshaken split or, better still, sawn shingles of teak, 15 inches × 5 inches, 1 inch to 1¼ inches thick, laid on battens 2 inches × 1 inch, placed 5 inches apart center to center, and nailed down in the usual manner.

2. The shingles to be first steeped in boiling coal tar and then dried. To be then laid carefully in line, overlapping each other 10 inches, breaking joint, and lying well one upon another to prevent rain being driven through between them.

3. Each shingle is to be bored to prevent splitting, and fastened down with 2 nails into the center of the battens.

4. The ridging must consist of galvanised sheet iron or zinc, overlapping 1 foot on each side, and securely fastened down with galvanised nails or screws and washers complete.

5. Shingles should be washed annually with Rangoon oil.

10. Tar and Sand for Terraced Roofs.

1. The best tar, free from oil or liquid, to be procured. This will be boiled in caldrons or chatties and into it will be stirred *hot sand.* The sand is heated in order to drive out any moisture. As much sand is to be stirred into the boiling tar *as possible,* that is, until the mixture becomes too stiff to stir any longer. The mixture is then ready for immediate application.

2. The finer the sand the better, so long as it is quite sharp and clean.

3. The upper surface of the masonry to be smoothed with a thin rough coat of plaster, merely filling up inequalities and hollows. When this is *thoroughly dry,* the tar and sand to be prepared and applied.

4. Thickness of tar and sand mixture to be only one quarter of an inch, and this will be applied in the same manner as plaster with trowels and a smoothing board, as used for asphalte, to render the surface quite smooth.

5. When thoroughly set, which will require some ten days or more, according to climate, if on a roof, the surface must be washed with two coats whitewash, which will have to be done annually in fine weather.

XVIII.—FLOORING.

1. Brick on edge Flooring.

1. The surface to be excavated to the depth necessary, carefully levelled and well rammed down. On the bed thus prepared a layer of 3 inches of sand on which a course of brick in mortar to be laid flat. The brick on edge to be then laid very carefully, either in parallel row breaking bond or in herring bone bond.

2. Or, 6 inches of brick concrete of proportions to be specified by the Executive Engineer to be laid over the earthen bed and well rammed. Over this bricks on edge as above.

3. The joints to be rubbed, and the best burnt bricks to be selected. The mortar joints not to exceed $\frac{3}{8}$ inch, and when surki or hydraulic lime is used the bricks to be thoroughly wetted before being laid.

2. Tile or Square Brick Flooring.

1. The bed to be excavated and prepared as above, and a layer of 6 inches of brick concrete to be laid and well rammed down. Over this, paving tiles or bricks, sound, well-shaped and thoroughly burnt, to be laid, and set in mortar so as to break joint. Care to be taken in all cases that a perfectly even smooth floor is obtained.

3. Chunam or Terraced Flooring.

1. The bed being prepared as above, a layer of brick concrete of proportions specified by the Executive Engineer, 6 inches thick after beating to be laid and well rammed for three consecutive days with wooden beaters, four coolies per day per square being employed.

2. When the consolidation of the concrete has been satisfactorily completed, a layer of plaster of proportions specified by the Executive Engineer to be laid evenly over the surface and well beaten down with flat beaters for three days, four coolies per day per square being employed.

3. A thin coat of very fine plaster to be then floated over the surface and well rubbed in and polished with soap-stone till perfectly smooth and hard. Care to be taken to keep the surface moist by covering it with damp straw, and to prevent it drying unequally until the whole is completed and fit for exposure.

4. Cement Concrete Flooring.

1. To be laid as the last, the proportions of ingredients being eight parts of broken stone, three parts of river sand, one part of Portland or Morgan's cement.

2. The sand which should be clean and sharp to be damped, and the stone, broken to 1½ inches cubes, to be well wetted. The sand and the cement to be well mixed together, the broken stone to be then added, and the whole mixed thoroughly. To be then laid and thoroughly rammed as specified above to the required thickness. As little water to be used as possible.

3. The surface to be then plastered with a thin coat of the cement, which should be kept watered for ten days.

5. Stone Flooring.

(See "Stone Flagging" under Sub-head "Stone Masonry.")

6. Asphalte Flooring.

1. To be laid on an unplastered flooring of concrete prepared as above. The concrete to be perfectly dry before the asphalte is laid.

2. The surface to be thoroughly cleansed of all dust, dirt, and sand; and the asphalte, mixed in proportion which will be specified by Executive Engineer to suit the locality, traffic, climate, &c., to be laid on smoothly and evenly (½″ or ¼″ as ordered), and to be carefully and steadily rubbed with a hand float until the surface is perfectly even and true.

3. The junctions of the sections of the asphalting to be carefully made, and before the surface becomes hard to be worked off perfectly level and smooth with fine clean sand, and to be left of a uniformly dark color.

7. Tar and Sand Flooring.

1. To be laid as specified for tar and sand roofing, but the sand to be rather coarse. Three inches of concrete, spread and rammed over the bed prepared as for chunam floor, will be found generally sufficient.

8. Minton's Tiled Flooring.

1. The pattern of tile to be approved of by the Executive Engineer. The concrete bedding as above to be evenly covered with a coat of mortar and truly levelled after an interval of two or three days. The tiles to be set perfectly true in Portland cement on the surface thus prepared. For every 100 square feet of tiles not less than three-fourths of a cask of cement should be used.

2. The floors should be thoroughly washed within ten days of completion of each portion, and handed over clean.

9. Wooden Flooring.

1. To be of the best teak boards, thoroughly seasoned, and of the greatest length procurable.

2. Boards to be 1¼ or 1½ inches thick as ordered, and from 4 to 6 inches in width. To be tongued and grooved, or tongued and ploughed, or plain jointed, rebated, or rebated and filleted, as may be specified.

3. Heading joints to rest upon the joists below, to break joint with one another, and to be rebated and tongued together. Each board to be secured in its proper position by two 2½ inch screws screwed to the widging joists below.

4. The heads of all screws to be countersunk, and the exposed surface then planed quite smooth.

XIX.—METAL WORK.

1. Iron Work.

1. *All cast iron work* to be clean, sharp, sound, and free from cracks, flaws, sand or air holes, or defects of any kind, with a fair and even surface. To contain not less than 50 per cent. of No. 1 pig iron, and to be sufficiently soft to admit of being easily cut by either chisel or drill.

2. Moulds and patterns to be supplied by the contractor unless otherwise specified, but in any case the responsibility for the accuracy of the castings in size and dimensions shall rest with the contractor.

3. Holes for bolts, &c., shall be drilled out or cast in the casting as may be directed in each case.

4. *All wrought-iron work* to be carefully, cleanly, and soundly forged, not overheated or burnt. To be of best English bar and plate iron: rivets to be of Lowmoor, Bowling, Swedish, or approved Native Indian iron. Tie-rods for trusses or arches to be of S.C. crown, Bowling, Lowmoor, or Swedish iron.

5. The work to be made accurately to the dimensions shown in the drawings; all welds to be carefully examined and any not perfectly sound rejected.

6. No iron shall be used in girders or similar work that will not bear an ultimate tensile strain of 22 tons to the square inch; and all bolts, tie-rods, tension bars, straps, &c., shall be tested with a proof tensile strain of 10 tons to the square inch. Any articles which show sign of failure under this test to be rejected, and such shall not be repaired and again submitted for test except by special permission of the Executive Engineer in writing.

7. Holes for bolts and rivets shall always be drilled when made by the hand, and shall only be punched where proper machinery is available. All rivets shall be firmly clinched whilst hot, and left with a neat clean head free from cracks or flaws.

8. Straps and collars shall be shrunk on, so as to make them fit firm and tight.

2. General

1. All headed bolts passing through plates to be accurately fitted to the holes, with the heads lying squarely and closely on the plates. The heads to be forged in one piece with the bolts. Rivets must be tightened and drawn closely home, and the heads spread equally and properly hammered and set down all round.

2. All screws to be cut with a clean full thread without taper, and to an accurate fit.

3. Nuts when measured from side to side to be at least twice the diameter of the bolt, and to be greater in depth than the diameter of the bolt.

4. All iron work during the whole course of manufacture shall be subject to the inspection of the Executive Engineer or those nominated for the purpose.

5. All iron work to be coated while hot with boiled linseed oil or painted with two coats of red lead as the Executive Engineer may direct.

6. No iron work shall be painted before it has been examined by the Executive Engineer or inspecting officer.

3. Erection.

1. The Executive Engineer may order the completion and fitting together on the ground of such portions of work as he may deem expedient, and may cause the same to be subjected to proper tests before it is put into position.

2. In putting iron work together the greatest care is to be taken to fit the plates and bars accurately in contact, and to see that rivet and bolt holes correspond before riveting up. All joints to be perfectly cleaned and freed from rust; should any parts be bent or injured, they are to repaired according to the instructions of the Executive Engineer. No holes to be rinsed out without the special permission of the Executive Engineer, and then the rinsing out is to be done with a semicircular bit not drifted, and larger rivets or bolts must be used to fit the holes.

3. In erecting girders the different parts are to be fitted together with service bolts, and packed up to camber before riveting is commenced; care to be taken to keep the girders laterally straight.

4. In fixing bed plates, special care must be taken to put the holding down bolts exactly in position, so that the nuts may bear square, and firmly grip the plate below. The upper surface of bed plates or rollers must coincide exactly with the level given by the Executive Engineer. The bed plates to be set in mastic or cement as the Executive Engineer may direct, the cost of which must be included in the rate for fixing.

5. After the passing of any iron work by the inspecting officer, the whole shall be thoroughly cleaned and scraped clear of rust, and then covered with one coat of red lead and two coats of the best oil paint, the color of which will be determined by the Executive Engineer. All planed and turned surfaces to be covered with white lead and tallow.

XX.—PAINTER'S WORK.

1. *Linseed oil* used shall be limpid, pale and brilliant, mellow and sweet to the taste with very little smell and shall be boiled once or twice as directed. When country linseed oil is permitted to be used, it is to be boiled for two to three hours with red lead and litharge in the proportion of one pound of each to a gallon of oil.

2. The best way of boiling with litharge is to tie up the latter in a small bag attached to a stick and allow it to remain simmering in the pot of oil for 2 or 3 hours when it can be removed.

3. When ordered the linseed oil may be clarified by mixing it with oil of vitriol, after which it is to be well washed with water till quite free of the acid.

4. *Driers* to be used shall be litharge, sugar of lead, or red lead, as specified by the Executive Engineer.

5. *Putty* shall be made of whiting (see paragraph "Glazier's work") and oil, the whiting to be specially dry and passed through a sieve of 45 meshes to the inch, and then mixed with as much raw linseed oil as will form it into a stiff paste; this after being well kneaded shall be left for twelve hours and worked up in small pieces till quite smooth. If the putty becomes dry, it should be restored by heating and working it up again while hot.

6. *Grinding colors.*—When a color mill is not available, the "grindstone" and "muller" shall be used. The grindstone to be a slab of granite or other stone about 2 feet square, hard and close grained, and the "muller," a hard and conical-formed stone with the diameter of the base or rubbing surface about one-sixth of that of the grindstone and the cone high enough to allow a sufficient hold for both hands, the faces of both grindstone and muller to be perfectly flat and smooth.

7. The colors shall be first ground up with a small portion of the oil, for which purpose they shall first be pounded and passed through a tolerably fine sieve, then mixed with a portion of linseed oil sufficient to saturate them; a quantity about the size of a small egg will then be placed on the grindstone and thoroughly ground by the muller being moved in all directions, after which it shall be removed and a fresh quantity taken and similarly treated, and so on till all the colors have been ground.

8. *Mixing colors.*—After grinding, the colors shall be rendered fluid by the addition of linseed oil or spirits of turpentine, or both, as specified by the Executive Engineer.

9. When tinted colors are required, a small quantity of the proper tint should be first prepared to serve as a guide by which to mix the whole quantity. The ground white lead shall first be well mixed with a portion of the oil, and then the tinting color shall be added to match the pattern thoroughly mixed, after which the remaining portion of the oil or turpentine is to be added, and the whole passed through fine canvas or a fine sieve. The consistency shall be that of cream so as to work easily.

10. When painting on wood, the work shall first be cleaned, all such projections as glue or whiting spots being carefully removed with the stopping knife and duster, after which all knots will be killed with one or more layers of oil and white lead or red lead and size or glue laid on warm and rubbed down when dry with sand paper or pumice stone.

11. The surface shall be thoroughly dry before the priming coat is applied.

12. The work shall then be primed with a coat of one part white lead to eight of whiting, ground and mixed together with four parts of twice boiled linseed oil.

13. In wood work, all holes, cracks, and nail heads shall then be stopped with putty, and irregularities reduced with sand paper and pumice stone.

14. Iron work shall be first thoroughly cleaned from rust and dirt, after which red lead alone shall be used as priming.

15. For other materials, when the work is to be finished in a dark color, the priming may be lead color; if to be finished orange, red, and similar tints, the priming may be pink.

16. Old work before repainting to be thoroughly cleaned with lime-wash if necessary and rubbed down with pumice, and all cracks filled with putty.

17. In the first coat over old work which is greasy from smoke, spirits of turpentine shall be used for mixing the color instead of linseed oil.

11. When necessary, the old paint shall be removed by applying a solution composed of—

Soft soap	½ part.
Potass	1 part.
Quicklime	½ or ⅓ part.

The soap and potass are first dissolved by boiling in water, the lime is then added, and the whole applied while hot with a brush covering all the paint to be removed with the solution which must be left on twelve to twenty-four hours, after which the whole of the paint will be easily removed by washing with hot water.

19. When the old paint has blistered or been chipped off, the surface is to be rubbed down and scraped, and then brought forward by three or four touchings with paint before the general surface is commenced.

20. All colors to be laid on evenly and properly with English made brushes.

21. Each coat of color to be allowed to dry thoroughly before the next is laid on, and all except the last coat to be slightly rubbed down with fine glass paper.

22. No hair marks from the brush shall be left on the work, or puddles in the corners of panels, angles of mouldings, &c.

23. White paint to be made of the best mineral white lead, five parts by weight, and Europe linseed oil three parts properly ground and mixed together with a small quantity of turpentine. A little Prussian blue to be added if directed.

24. Green painting shall be executed with the best Brunswick or marine green ; verdigris loses its color from exposure and shall not be used without written permission of the Executive Engineer. When used, the best mineral verdigris and white lead are to be employed in the proportion of 13 to 22 by weight, ground separately, screened, and mixed together.

25. Satin wood paint to be made of sixteen parts white lead, one of chrome yellow, one of red lead, two of red brown, two of amber brown, three-fourths of terra sienna, of Europe linseed oil, four of turpentine, and one of varnish. The yellow painting to be laid on in two coats as in white painting, and the figures carefully inscribed after it is dry.

26. Mahogany painting color, to be mixed as for satin wood painting, with the addition of a little ivory black. The color to be laid on in two coats and the figures carefully inscribed after it is dry.

27. Red paint to consist of two parts red ochre, three of mineral red lead, and four parts of wood oil ground and mixed.

28. Black paint to be composed of one part chalk, half part of white lead, one-fourth of wood oil mixed with lamp black.

29. Varnish to be Copal varnish or such other as may be specified by the Executive Engineer.

30. The following compositions make approved varnishes :—

a	Rosin	2 parts.	For common work.
	Europe linseed oil	2 parts.	
	Spirits of turpentine	1 part.	
b	Copal	3 parts.	
	Oil of turpentine	5 parts.	
	Linseed oil	2 parts.	

c	Amini resin	2 lbs.
	Litharge	1 oz.
	Sugar of lead	1 oz.
	Spirits of turpentine	5½ quarts.
	Linseed oil	3 quarts.
d	Pale shellac	7½ parts.
	Mastic	6½ parts.
	Spirits of wine	10 parts.

31. *Painting on Plaster.*—The plaster to be quite dry and hard and well sized.

The first coat to consist of white lead diluted with linseed oil to a thin consistency with a small quantity of litharge;

Second coat to be also thin, so that the plaster may be thoroughly saturated;

Third coat to be thicker and to contain a little turpentine with some of the coloring pigment;

Fourth coat to be as thick as it can be used, equal parts of linseed oil and turpentine being used with sugar of lead as the drier;

Fifth finishing or flatting coat to be of pure white lead colored with pigment to the required tint and diluted with spirits of turpentine only.

32. Wood oiling, when employed as a substitute for painting timber work, to be of linseed oil with a small quantity of dammer boiled up with it or red ochre.

33. For coal tarring to wood or iron work, the coal tar is to be heated nearly to boiling point, thinned by the addition of half a pint of common country spirit to each gallon of tar, and while still very hot applied like paint with a brush, the surface being first well cleaned. When possible to remove iron work for the purpose, it will be heated to little short of a red heat and then brushed over with coal tar; iron work which cannot be heated will be painted with hot tar and spirit as specified for wood. The quantity to be used is not to be less than 10 lb. per 100 superficial feet.

34. *Varnish for iron work or out-door wood-work.*—The following may be used:—Dissolve in about 2 lb. of tar oil, ½ lb. of asphaltum and a like quantity of pounded resin, mix hot in an iron kettle taking care to prevent contact with the flame. When cold use.

35. Painting will be paid for at a rate per 100 square feet according to color and number of coats.

36. Moulded work of all kinds, unless otherwise stated, will be measured by running the tape into and over all elevations and depressions, but doors and windows will be measured flat over all including architraves, &c., if any.

37. Venetians will be measured as one and a half times the area of the flat surface of the same size; glazed portions of doors and windows to be allowed for by deducting half of the glazed part from the total area.

38. All work that cannot be measured shall be agreed for by the job or may be executed under supervision of the Executive Engineer by workmen supplied by the contractor, to be paid by the quarter, half, or three-quarters of a day according to the time occupied in the job.

39. *Papering.*—The paper to be of the pattern approved of by the Executive Engineer. The walls to be carefully scraped and rubbed down quite free from any color wash or dirt.

40. If expensive paper is used, the walls to be first covered with a coating of lining paper; wall to be quite dry before the paper is applied.

41. The paper to be applied with paste made of best flour and water and a little size or glue, blue stone or sulphate of copper being added to prevent the attacks of insects. A little alum should also be added to make the paste spread and flow more easily. The greatest care required in fitting the pattern and in keeping all quite clean.

42. The paper when applied to the wall to be smoothed down by a roller covered with clean flannel, and not by the hand.

43. To prevent stripping, tape may be tacked on with copper tacks over the paper but under the border along top and bottom of wall.

XXI.—GLAZIER'S WORK.

1. The glass when not otherwise specified to be C.C. crown glass, free from all knots and defects, to be set in good putty, and the rabbit to be neatly chamferred; in ordinary glazing the glass is to be 16 ozs. per square foot.

2. All glass supplied to officers' quarters, dwelling houses, and important Government buildings, shall be patent flattened sheet glass of the best quality, weighing 21 ozs. to the foot (superficial).

3. All putty to be of the best whiting, and prepared as specified in paragraph 3 under "painter's work," and to be colored to suit the work.

4. The whiting is to be prepared by grinding chalk under a runner, then washing it to remove sand and other impurities, and lastly drying it in lumps.

5. All squares to be cut to fit the rebates of the sashes truly.

6. All glass to be properly bedded, puttied, and pinned to the frames with at least four pins to each square, and finished in a neat and workmanlike manner. No glazing to be considered complete until all stains have been removed from the surface of the glass This to be done without extra charge for squares set by the contractor.

7. No glass to be inserted in frames until they have been primed and prepared for painting, that the putty may adhere properly.

8 All glass squares that may have been set by the contractor shall, if they become loose during one year, be refixed and puttied by the contractor without extra charge.

9. The contractor shall make good any glass broken by his work-people whilst cleaning.

10. Job work, such as refixing old glasses, will be paid for at so much per job ; or the contractor will have to supply labor and material at the schedule rates, the work being executed under departmental supervision.

11. *To soften putty,* take 3 lb. of quicklime, slake in water, add 1 lb. pearlash, and make the whole of the consistency of paint; apply to both sides of the glass and let it remain twelve hours, when the putty will be so softened that the glass may be taken out.

XXII.—PLUMBER'S WORK.

1. All lead in gutters to be not less than 5 to 8 lb. to the foot (superficial) ; in hips and ridges not less than 6 lb.; and in flashings not less than 5 lb.

2. All gutters to be of cast lead; hips, ridges, &c. of milled lead.

3. Longitudinal joints in lead work to be formed on two inch wooden rolls.

4. The joints at right angles to the current to be formed by a drip with a proper lap or by a 3 inch joint of folded lead.

5. Copper nails to be used in fastening lead to wood work.

6. All gutters to have a fall of at least half an inch to the foot, the ends and sides turned up against walls not less than 7 inches, and under tiles or pent-roof of any sort to the same level ; turnings up to be covered with a flashing.

7. All fittings of water-closets must be of the best English make, and the schedule rate will be a percentage rate on the invoiced price, to include all charges of freight, carriage, and fixing in position.

8. All brass, copper, and other cast metal work, in watercocks of all descriptions and in elbow joints, valves, nozzles, washers, plugs, ferrules, &c., to be paid for by weight, to include all fitting and putting up.

XXIII.—DRAINAGE OF BUILDINGS.

1. In all large buildings the rain water from the roofs will be taken off by means of gutters, down pipes,or spouts communicating with drains, laid so as to carry the water away from the site of the buildings.

2. Gutters to be laid in 5 to 8 lb. lead according to situation, with a minimum slope of 1 inch in 10 feet, and to be properly connected with the heads of the rain pipes, which with all upper sinks, &c., for receiv-

ing the first discharge from the roof require to be as wide, deep, and open as possible, so as to prevent stagnation in delivery of the drainage, and also need perforated plates to keep out leaves, &c., which might otherwise choke the down pipes. The lead in gutters or valleys is to turn up under the tiles or covering at least 12 inches, and the lap of the flashings to be 6 inches unless otherwise specified.

3. All junctions and joints to be sound and thoroughly water-tight.

4. Iron gutters will be of sheet iron galvanised or painted bent on a core. The joints to be made by riveting on externally a piece of iron of the same shape, the ends being first made to butt clean and sharp. These gutters will be firmly fixed with screws to the end of the rafter, or against the side of the pole plate as the case may be. Those formed in masonry will be laid with a coat of fine plaster, the wall being strongly corbelled out to carry them.

5. Stone gutters will be of 1 inch flags, dressed, laid in as long lengths as is procurable. The side will be secured to the bottom piece by dovetails 2 inches wide, placed 12 inches apart, and they will be put together with the best lime cement ground to a fine paste. The vertical joints in the sides will be so arranged as to come opposite to each other and at the same time break joint with those in the lower piece; these latter shall always come over a corbel. All these joints will be made half lap and will be put together with fine stone lime. To keep the sides together, holding pieces 6 inches wide will be inserted at intervals of 3 feet: they will be neatly and firmly dovetailed into each side and set with cement.

6. Corbels carrying gutters will be built into the wall for a distance equal to one and a half times their projection.

7. Wooden gutters will be made up in a similar manner, the joints to be put together with red lead. They will be carried on stone corbels or on wooden cantilevers according to the specification of the Executive Engineer.

8. Rain water down pipes to be of cast iron and placed where specified by Executive Engineer; the joints to be filled with Portland cement or putty.

9. Bends may be of sheet lead, neatly made, and approved by the Executive Engineer.

10. The pipes to be fixed to the building with strong flat-topped nails 8 inches long, with neatly rounded heads; proper iron straps shall be provided for the places indicated by the Executive Engineer.

11. In very important public buildings, the drainage may be taken down through the walls by means of copper pipes in such manner as may be specified by the Executive Engineer. Large sinks above, and absolutely perfect jointing throughout, are here essential to prevent dampness resulting.

12. Price to include all connections, bends, fittings, holes in walls and floors, as well as all painting required.

13. Wooden down pipes will be square in section, of 1 inch planking, well jointed, put together with red lead, and secured with screws to ordinary hold-fasts firmly fixed in the wall.

14. For short drops or in out-houses, simple recesses in the wall will suffice. They will have a coat of fine plaster floated over them.

15. For small buildings, continuous stone shoots or spouts of iron, tin or earthenware, may be used. They shall always discharge at least 2 feet from the wall, so as to save it from being discolored.

16. Shallow gutters will be laid in all upper verandahs, just inside the outer wall, to carry off accumulations of water from tatties, rain, &c.

17. They will communicate with the nearest down pipe or outfall drain, and the floor of the verandah will be sloped down towards them with a fall of 1 inch in 4 feet. The doors of all lower verandahs will be laid with a similar fall.

18. The floors of all bath-rooms and water-rooms will be laid with a similar slope, and will have a communication with the nearest down pipe or outfall drain.

19. Stone sinks communicating with the nearest drain or down pipe will be provided in the verandahs of all married quarters, sergeants' quarters, and similar localities.

20. All the above drains, down pipes, and spouts will communicate with shallow drains of masonry 6 inches deep and from 12 to 18 inches wide, as specified by the Executive Engineer, laid at a distance of 2 feet from the wall. Outfalls from these will be laid to the nearest main drain or stream, and the space between them and the building will have a coat of metalling of such description as shall be specified, laid down and thoroughly consolidated.

XXIV.—WOODWORK.

1. "Carpenter's work" includes all timber in roofs, floors, verandahs, staircases, door and window frames, bridges, centerings, cofferdams, curbs of wells, shores, struts, large gates, and generally all woodwork of which the scantling exceeds three sectional inches and which is not specially moulded or carved.

2. When the thickness of carpenter's work does not exceed two inches, and at the same time the width exceeds twice the thickness, it is called "planking."

3. "Joiner's work" includes furniture, doors and windows pannelled, turned, carved, or moulded work of all kinds.

4. Carpenter's work is rated per cubic foot, except planking, which is rated by the square foot of a specified thickness, or by a certain number of running feet with specified breadth and thickness. Doors, windows, and similar work, and pannelled work generally, are rated per square foot; other joiner's work at special rates, according to the nature of each case.

5. The timber generally used for carpenter's work in the Bombay Presidency is teak, and except where other kinds of wood are distinctly specified, teak alone is to be used.

6. The source from which the timber is procured is to be approved by the Executive Engineer; the timber is to be of the best quality, well seasoned, felled for not less than two years before use, free from large or loose knots, from shakes or defects of any kind. Heart or sap wood will be rejected. Any timber so rejected shall be removed at once from the site of the works, and not again brought thereon unless by the express written permission of the Executive Engineer.

7. The Executive Engineer may inspect all logs previous to use, and reject any which he considers defective in the conditions specified in the foregoing paragraph.

8. Carpenter's work is ordinarily specified as "wrought" or "wrought and put up," or "wrought, framed and fixed."

9. The rate for wrought timber includes carriage to, and delivery at, the site of the works, the *fair* rendering of all surfaces, chamfering of angles, &c., and the execution of all framing in exact accordance with drawings or other directions given by the Executive Engineer, the construction and fitting of all joints, the putting together of all truss and other framed work, the provision and fixing of all nails, screws, and brads, and the fixing, but not the provision of straps, bands, and screw bolts, shown by the working drawings or *bonâ fide* forming a portion of trusses or other framed work.

10. The rate for timber "wrought and put up" includes all that specified in the preceding paragraph, and in addition all work required for fixing the timber in its proper position in a building, bridge centering, or other construction; under this head is included all special scaffolding labor, materials, and apparatus for lifting and fixing in position according to the drawings or other instructions furnished by the Executive Engineer.

11. All workmanship is to be of the best description, and all joints must fit accurately without wedging or filling.

12. Planking is to be supplied with straight and square edges, or rebated, ploughed, and tongued or dowelled as may be directed.

13. All carpenters' work will be paid for by net measurement, no allowance being made for wastage or for dimensions supplied beyond those specified, but the length of each piece will be measured over all so as to include projections for tenons or scarfs.

14. The rate for framed wood-work to include all sawing, planing, jointing, framing, labor, and materials, for raising and fixing, and workmanship, also the fitting, fixing, and supply of all straps, bolts, nails, trenails, spikes, screws, &c., necessary for the framing and fixing.

15. The contractor will give due notice to the Executive Engineer when any timber is to be covered in the ground or in the walls of a building or otherwise, failing which it shall be optional with the Executive Engineer to order the same to be uncovered at the contractor's expense or to measure and pay for only so much as remains uncovered.

16. No timber work shall be painted, tarred or oiled without the previous permission of the Executive Engineer.

17. The Executive Engineer may order any truss or other framed work to be put together on the ground and submitted to suitable tests before being placed in position.

18. When unwrought timber is supplied by a contractor, the rate paid will in all cases include carriage to, and delivery at, the place where it is required for use.

19. Timber in the log, or wholly or partially wrought, may be supplied to the contractor from Government stores or from a dismantled building; in such case the value of the timber so supplied, at the rate payable to the contractor for similar material, will be deducted from the price of the finished work. Where the contract schedule contains no rate for similar material, the value to be deducted will form the subject of special agreement.

20. A separate rate will be required where material thus supplied has to be reframed or refitted.

21. Where material is supplied to the contractor under either of the two preceding paragraphs, he will be charged for its full dimensions, no allowance being made for wastage in working or altering it; and all of such material not used and charged for as finished work will be the contractor's property, but the latter shall be entitled to appeal to the Superintending Engineer if required to utilise such material as is in his opinion unsuited to the purpose intended from excessive wastage or other cause.

22. The conditions detailed above will apply to joiner's as well as to carpenter's work, except where they are plainly inapplicable.

23. All timber resting on, or bedded in masonry to be well tarred with boiling coal tar.

24. The ends of the timbers set in masonry shall have a space left on either side so as to give the air free circulation round it.

25. No wood-work of any sort shall be set within 2 feet of a fireplace or flue.

II.—IRRIGATION BRANCH.

XXV.—Large Reservoir Dams of Earth-work.

EARTHEN DAMS.—1. To consist (unless otherwise expressly specified) of an embankment with puddle and concrete trenches.

Section.

2. The section of the dam to be that used as a standard in the Department, or as shown in the drawings.

Preparation of the Site.

3. The embankment site to be first cleared to its full breadth of all trees, shrubs, grass, rubbish of all sorts, loose stones and soft stuff. The loose surface soil is then to be scraped off to a depth of at least 4 inches, and all roots to be dug out.

Where the line of the embankment crosses the feeder or river bed, the gravel and sand on the up stream side of the concrete or puddle trench is to be carefully removed down to some solid material.

The material of the bed on the down stream side of the trenches may, however, be left if it is firm and unlikely either to compress or shift in case of leakage from springs.

The material taken out as above directed and from the puddle and concrete trenches is to be carried clear of the dam site, unless other wise directed by the Officer in charge of the work.

Construction.

4. The embankment is to consist of a water-tight "hearting" of clay with a "casing" of mixed clay and moorum or gravel covering the slopes as a protection from the weather.

Clay Hearting.

5. The "hearting" to be the best and most retentive clay procurable within one-half a mile of the site, unless otherwise specified. No excavations to be made on the inside of the dam nearer the toe of the slope than twice the height of the dam opposite, nor on the outside of the dam nearer than 3 times the height of the dam. Nor is any excavation close to the dam to exceed 5 feet in depth.

The clay must be free of salts, large stones, moorum and rubbish of every kind.

The "Casing".

6. The casing is to be of the above clay artificially mixed with equal parts of gravel or moorum; or it may be of any good natural clayey gravel procurable on the spot. All stones larger than a hen's egg to be rejected from the material used.

Note.—Pure stiff black soil is found to answer best for reservoir embankments.

When the mixture is made by hand, the materials are to be placed clear of the work, the dry moorum and clay are to be laid over each other in layers of not more than 6 inches deep, they are then to be mixed with a powrah by turning the stuff over and over; the mixture is then to be carried in baskets to the embankment, and again mixed and spread with powrahs in layers of the proper depth as specified hereafter.

Forming Embankment and Consolidation.

7. The forming and consolidation of the embankment is to proceed as follows:—

The site having been properly prepared and well watered as specified, the materials of both the hearting and casing are to be spread evenly in layers of between 4 and 5 inches, or such thickness as will roll down to about 3 inches when finished. The relative breadth of hearting and casing to be as shown in the standard section.

When the first layer is complete it is to be rolled, it is then to be thoroughly soaked with water, and the second layer of dry material spread, this is in turn to be rolled and wetted and a third dry layer spread and rolled and wetted, and so on till the dam is complete. In places where rollers cannot be worked or cannot reach, such as in edges and corners, the stuff is to be consolidated with heavy rammers (if possible made of iron).

Rolling.

8. Rollers may be of stone or iron, but of such a size and weight that they will give a pressure of between $\frac{3}{4}$ of a ton and 1 ton per foot in length of roller.

The rollers should be kept clean so as to prevent the material sticking to them.

Ramming.

9. When embankments cannot be properly rolled, the earth is to be spread in 3-inch layers and well wetted; when the surface has begun to dry so that it will not lift under the rammer, it is to be sprinkled with dry material, and the ramming is to be carried on by lines of work-people working forwards and backwards on the surface till the layer has been thoroughly consolidated. The rammer heads should, if possible, be of iron, and should weigh about 14 lbs. Layer after layer is to be treated as above till the work is complete.

Junctions of Earthwork.

10. When new embankments are joined to old, the old work surface is to be removed to a slope and the junction to be dug up 2 feet deep, and both new and old stuff well watered and rammed.

PUDDLE TRENCH—1. A trench for the puddle is to be excavated with vertical sides along the centre line of the dam embankment.

Excavation.

2. The excavation is to be carried down till the solid rock or some other impervious material, such as "Mán Earth", approved by the Engineer, is met with.

The excavation below the surface of the rock or "Mán" is to be carried on with slopes of 1 to 1 for two or three feet deep.

The sides of the trench to be carefully shored up when necessary; the lengths of trench opened out should not be more than can be quickly filled in.

Vertical steps, longitudinally in the trench, are to be avoided; level stages with steep inclines between being preferable.

Size of Trench.

3. The breadth of the puddle trench, when not otherwise specified, to be $\frac{1}{10}$ the height of the dam + 3 feet.

The surface soil for 2 feet deep is to be removed on both sides of the trench for an equal breadth with the trench and refilled with selected clay well watered and consolidated as in the case of the rest of the embankment.

Springs.

4. All springs of consequence in the trench to be carefully plugged up or caulked before the puddle is laid.

The Puddle.

5. The trench, when ready, is to be filled in with good puddle made out of clean, tough, retentive clay. Soft, sludgy, peaty, sandy, salt, or puffy clays to be rejected.

Moorum is not to be mixed with or allowed into the puddle clay, and all stones larger than a hen's egg, and all grass or rubbish are to be carefully removed.

Gravel may be added to the puddle clay in proportions not exceeding 1 to 1 when the trench is wet, or in a less proportion if necessary on economical grounds and with the consent of the Engineer.

Laying the Puddle.

6. The clay generally may be put into the trench, in layers not exceeding 9 inches in depth, and there worked up with powrahs and men's feet and a little water into a stiff doughlike mud; but where the trench is deep, or there is little room to work, the puddle should be tempered upon the surface and thrown into the trench in balls, and there worked up as above. The layers of the puddle to be kept as level and uniform as possible. Puddle is never on any account to be allowed to dry. Should the surface of the puddle crack at any time, the craked surface is to be dug up and the puddle re-made.

Ramming the puddle.

7. As the surface of the puddle layers dry up they should be consolidated with rammers.

When the puddle is finished it should be at once covered up in the work, or, when this is impossible, with wet earth or grass.

Concrete Trench.

8. At the crossing of the river or feeder, a concrete trench 5′ wide is to be excavated on the down stream side of the puddle trench and from 15 to 20 feet clear of it.

This trench is to be excavated down to the solid material of the bed, rock, "Mán" or clay, and as far into it as in the case of the puddle trench or as may be directed by the Engineer.

The trench is to be filled with concrete as in Specification No. XXVII.

The concrete in the trench is to be carefully joined into the puddle of the puddle trench, as shown in the plan.

PITCHING.—1. The pitching is to be set on the water slope of the embankment from the level of 2 feet below the sill of the outlet sluices to 3 feet over the highest flood level, unless otherwise specified.

2. The stone to be good, hard quarry or boulder stone such as will not weather on the surface. It is to be roughly squared with the hammer so as to ensure the stones fitting fairly one on the other so as not to expose the earth-work below.

Stone.

3. The stones are to be laid with their broadest faces downwards, firmly bedded in moorum, and packed up with chips of stone to form an uniform slope.

Laying.

The use of chips to be confined to the bed on which the stones rest, and no pinning is to be allowed between the sides of the stones which are to be packed with the hammer or mallet close against each other, their general lie being approximately perpendicular to the slope of the face of the bank.

The depth of the pitching, unless otherwise specified, to be 6″ at bottom of slope, increasing uniformly by increments of 3 inches to 1′-9″ at highest flood level, and again decreasing in the same way to 9″ at top.

Size of stone.

The depth of the pitching to be represented by one stone only.

4. The face slope of the pitching when complete is to be that specified for the face of the dam, so that the varying depth of the stones must be allowed for in the earth-work and adjusted in the moorum bedding.

Slope.

The surface of the work when complete shall be left clean of all refuse, and have a fairly neat appearance.

XXVI.—Masonry Dams.

1. The masonry of dams is to consist of rubble stone of a durable nature, laid in mortar of hydraulic lime and clean sharp sand, and to be of the following classes, *viz.*—

Details of Construction.

(1) Front casing of hammer squared rubble masonry-facing backed with uncoursed rubble.
(2) Back casing of uncoursed rubble.
(3) Hearting of uncoursed rubble or concrete.

2. The casing in front (outer face of the dam) to average 3 feet in thickness, and to consist of a facing of hammer squared rubble laid at right angles to the face plane and a backing of coursed rubble masonry.

Face casing.

Masonry Dam.
Sectional Elevations.

Fig. I.
Casing of hammer squared rubble facing with rubble backing and concrete hearting.

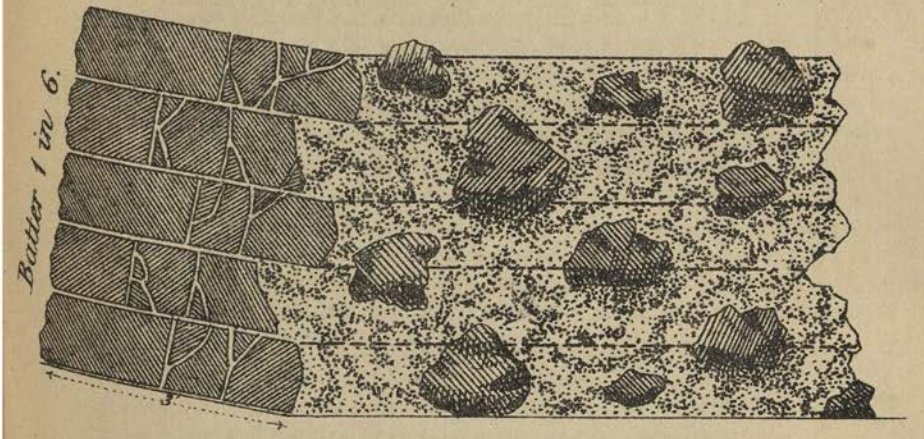
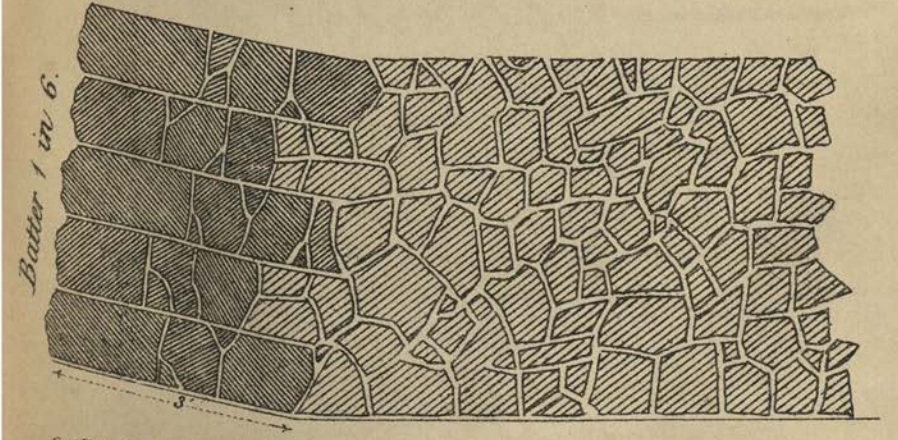


Fig. II.
Casing of hammer squared rubble facing with rubble backing and uncoursed rubble hearting.



Govt Photozinco. Office, Poona 1886.

The facing to be as specified in No. XXXVIII. and to bond well with its coursed rubble backing, each stone of which is to be of full depth of the course, *i. e.* from 7″ to 10″, with parallel beds, but having side joints of any form.

Mode of laying.

3. The stones are to be fitted together as closely as is possible without much dressing.

The stones in alternate layers of the casing must break joint and bond in every direction: all stones to be well wetted before laying in mortar, and then driven down and into contact with the adjacent stones by a light mallet. The spaces between stones in the backing to be filled with mortar, and then wetted pinners or chips of stone to be inserted so as to save mortar and increase the weight of the masonry.

Finishing.

4. The face joints to be neatly struck with a trowel, but not pointed or raised. The back of the rubble of the casing is to be left rough, so that the stones may bond into the hearting of uncoursed rubble, or concrete, used to form the centre of the dam.

Back Casing and Hearting.

5. Uncoursed rubble (in the interior or hearting of the dam or back casing) to be as specified in No. XXVIII. except that the surface of the work is not to be brought to an uniform level, but is to be bedded and driven home, stone upon stone, by a mallet.

6. The hearting is to be laid and bonded closely into the casing as soon after the latter is built as possible, and it will extend horizontally between the inner edgings of the casings.

Foundations.

7. The foundation of the wall is to be excavated well into rock everywhere, (and at any place subject to an overfall, well into rock of the hardest description); then to be dressed to a slope, so that the foundation courses of the casing may have its upper surface at right angles to the face of the dam.

XXVII.—Concrete in Dams.

Material.

1. This is to consist of broken stones, pebbles, and clean gravel or shingle intimately mixed with mortar of hydraulic lime after being well wetted.

The materials should be of all sizes up to what can be conveniently turned over and rammed.

The proportions should be chosen so that all interstices are filled up completely, and mortar just creams up on being rammed with light rammers.

Note.—Hill stone should weigh about 184 lbs. per cubic foot, and quarry stone the same; any trap rock weighing less than 175 lbs. should not be used in face work.

Uncoursed rubble is to be used as filling in all parts of the dam that may be subject to more than 60 lbs. of pressure on the square inch, and as the back, or water face casing, of the dam when concrete hearting is used.

2. The mortar will generally consist of two parts of sand to one of lime, and the usual proportion of the concrete (unless otherwise specified) will be:—

Proportion.

Metal	...	...	... 2 parts	6 parts.
Shingle	...	...	... 2 ,,	
Pebbles	...	...	... 2 ,,	
Mortar	...	...	... 3 ,,	

3. These are to be turned over and over on a platform, or in a mixer, seven times at least. It is to be laid in courses equal to those of the face work on alternate days; the adjacent masonry being well wetted and the concrete carefully pushed in with pointed stakes so as to join it and the casing closely. If more than a day has passed since the masonry was built, mortar should be thinly plastered on its edges after they have been wetted, so that the concrete may take hold and unite to it firmly; this provision will seldom be necessary, as the hearting work should closely follow on the casing.

Preparation.

Note.—Concrete may be used for all parts of the interior of the dam where the greatest pressure cannot exceed 60 lbs. on the square inch.

4. Heavy stones and boulders too large for mixing with the concrete may be inserted in it as it is being laid. These will bind the layers of concrete together, economise mortar, and add to the weight. They should generally form one-third part of the whole. They should be well wetted before insertion and also when the concrete is being laid about them.

Boulders built in.

5. All masonry and concrete is to be carefully watered and kept damp from the moment that the mortar in it sets sufficiently to allow water to be sprinkled on it safely.

Watering.

MORTAR.—1. The mortar for masonry and concrete is to be prepared as follows; well-burnt hydraulic lime is to be placed in the ghanee in an even layer, and to be well sprinkled with water, but not drowned. After an hour it is to be wetted thoroughly; at the end of the two hours it is to be stirred, and any unslaked lumps removed, then covered with water, and allowed to stand two hours more; in all, four hours. It is then to be ground for 3 hours, water being added whenever it becomes stiff.

Preparation.

2. Clean, sharp, and wet sand is then to be added in such proportions as may be found by experiment to be best, usually 2 of sand to 1 of lime, or otherwise as directed by the Executive Engineer. The sand and lime to be then ground together for two hours,—total grinding 5 hours.

Proportion.

XXVIII.—Masonry in Canal Drainage Works.

UNCOURSED RUBBLE.—1. The masonry used, to be of good, uncoursed, fitted rubble, consisting of sound building stone of at least

three-quarters of a cubic foot in size for face work, laid full in mortar with parallel beds, or nearly so, all through the work. The side joints are to be close for at least 3 inches from the face, and no two adjacent stones are to be of the same length; chips may not be put under stones, but are to be used to fill up interstices in the side joints so as to save mortar.

Bond.

2. A bond of at least six inches to be maintained throughout.

Watering.

3. All stones to be well wetted before being laid, and all work to be kept wet until the next course is laid on it.

ARCHING.—1. The arching of aqueducts is to consist of stones with beds parallel (approximately) to the summering, and well bonded at the side joints and ends. No stone to extend less than half the thickness of the arching, and the stone behind it may project beyond the arch into the backing, except at and near the crown, where the work must be very carefully laid, and ends of stone cut off, if necessary, so as not to obstruct the waterway. The ring pens are to be dressed on their beds only, and are alternately to bond well into the rubble sheeting and into the spandril walls. Near the crown they will meet the string course, and must be dressed roughly there for this to rest upon.

Construction.

Skew backs.

2. The skew backs are to be dressed only on their horizontal and skew beds. They are to bond back into the masonry of the abutments, cutwaters, and ease-waters.

Caps of piers and pilasters are to be dressed on their beds, and 4″ in from the face at side joints, and chamfered at their edges. The exposed surfaces are to be brought approximately to the forms shown in the drawings, scabbled or hammer dressed roughly. The stones of which cutwaters are formed, are to be bonded very carefully, not only one with another by breaking joint, but into the body of the work behind them.

CONCRETE.—The concrete to consist of broken stone, gravel, sand and hydraulic lime in the following proportions by measure:—

Metal	... 2 parts.
Gravel (large) ...	... ... 1 part.
Do. (small) ...	... ... 1 ,,
Sand	... 2 parts.
Lime	... 1 part.

The stones to be well wetted and then thoroughly mixed with the mortar, the lime having been previously slaked and ground with the sand for at least 7 hours. All concrete to be used fresh and to be well rammed in 9-inch layers.

POINTING.—1. Shall not be done except where expressly ordered by the Executive Engineer, but when so ordered it shall be as follows:—

2. The joints of the masonry shall be raked out to a depth of at least ¾ of an inch, cleaned of dust, and left open for inspection, and this part of the work shall be approved of before the pointing begins.

Raking out and cleaning joints.

When the filling in of the joints is in progress, the face of the work shall be well wetted and the joints kept damp.

3. The pointing shall be done with fresh finely ground mortar of the best description. The mortar shall be worked well back into the joints with the trowel, so that no hollows shall remain.

Hollows.

Note.—As a rule, pointing may be avoided if the joints be neatly struck or finished off by the masons as they build the work; in any case the pointing should be done while the mortar of the work is fresh and "green".

The pointing shall be finished off neat and smooth, raised or otherwise, as may be directed.

No false joints shall be allowed.

4. The work shall be screened from the sun and kept damp for 3 days, or till the mortar of the pointing has properly set and hardened.

To be kept damp and sheltered.

If necessary for this purpose, screens of grass or matting should be put up.

5. When not otherwise specified, the mortar used in pointing should be made with half the proportion of sand specified or used in the mortar with which the rest of the masonry is built.

Proportions of sand and lime.

6. Pointing of the inside, the parapets, flank walls, extrados of arches, tops of haunches of arches over piers and abutments and of aqueducts to be executed with Portland cement of approved description. The work shall be done as specified for above, only that the joints shall be raked out to a depth of full 1 inch, and the work finished off with special care, so that there shall be no leakage through the joints.

Pointing to be of cement in certain cases.

The Portland cement used shall be fresh, mixed with an equal bulk of clean fine (sifted if necessary) sand into a stiff mortar which shall be used before it has begun to show any signs of setting.

SLABS.—1. Slabs used for covering openings of superpassages to be full 6 inches in thickness throughout their entire length, and to have a bearing of at least 6 inches; the two outer slabs to have bearings of 8 inches.

Sizes.

2. These outer slabs forming the face to be neatly chisel-dressed, and all intermediate slabs to be roughly hammer dressed only.

Dressing.

3. The joints between the slabs to be carefully made up with chips and mortar, so as to make the work solid and close throughout.

Laying.

XXIX.—Canal Banks.

1. The canal embankments shall be of the general dimensions shown in the plans, and shall generally be made from material excavated from the cuttings; where this material is insufficient, it should be obtained from trenches excavated along the boundaries of land taken up for the canal.

Materials whence obtained.

2. The canal embankments shall be formed in 6-inch layers, each layer being thoroughly watered, and well rolled or rammed before the next is commenced.

Construction.

3. Spoil banks, that is banks made where the cutting is of a depth greater than the maximum depth of water in the canal, shall be neatly made of similar form and as far as possible of the dimensions as the canal banks, but may be made in layers 12 inches in thickness, and need not be watered and rammed.

Spoil.

4. A berm of 4 feet to be allowed between the toe of the canal bank or spoil banks; but where the canal is wholly in bank, these berms may be omitted.

Berm.

5. The side slopes of the canal in cutting to be as follow :—

Slope.

In soil	... 1½ to 1
,, soft moorum ...	... 1 to 1
,, hard ,, ...	... ½ to 1
,, rock	... ¼ to 1 or vertical.

6. Bed stones and stones on the banks of the canal to be placed at every 1,000 feet, and to be properly and consecutively numbered; the bed stones to be accurately laid to the "formation" level at that point.

Bed stones.

7. Mile stones to be fixed at the end of each mile and quarter mile to be placed near the boundary hedge, and to have a bench mark cut on the top.

Mile stones.

PITCHING.—Pitching where necessary for the protection of the slopes shall consist of stones of a prescribed thickness laid on moorum, by hand, on their base or broader end, and each stone shall be well and firmly bedded in its place.

XXX.—Laying Cast Iron Pipes.

1. The trenches shall be excavated along the lines denoting pipe lines, as shown in drawings, and are generally to be excavated to such depths as will admit of a minimum cover, that is depth of filling above the top of pipes, of 2½ feet.

Excavation of Trench.

2. The various materials excavated to be separated and placed, so that in refilling they may be again relaid in the same order, and thus the least possible damage will be done to public roads, cultivators' fields, &c.

3. After laying the pipes, as hereinafter described, the earth shall be filled in and around the pipes, and shall be carefully beaten and trodden down, so as to effectually secure them in their proper place: the earth shall then be filled in to the height of one foot above the pipes, and shall be watered and rammed thoroughly, the succeeding layers to be six inches in thickness, each to be thoroughly rammed and consolidated before the next is put on. The original surface of roads to be properly restored.

Covering in.

4. The pipes, before being laid, shall be brushed throughout, to remove any soil or stones that may have accumulated therein, the inside of the socket and outside of the spigot being carefully cleaned, and then shall be laid singly in the trench in a straight line, and bedded firmly on the solid earth.

Preparation of pipes.

Laying.

When the trench has to be excavated through rock, a layer of earth, about six inches in thickness, shall be placed between the bottom of the pipe and the rock. The pipes shall rest uniformly and firmly upon this bed throughout their whole length, and all shall be properly driven home, and shall be jointed in the following manner:—

5. Socket Pipes—

1st. One complete lap (at least) of white hempen spun yarn shall be forced to the bottom of the socket.

2nd. As many laps of white or tarred hempen yarn shall be tightly driven so as to leave a space of 2½ inches clear for the lead.

3rd. The remaining space, which should be previously dried, to be filled, at one running, full of good new lead melted from the pig. The lead to be run flush to the outside of the joint, and must be at least 3 times "set up", that is, caulked or driven up with properly proportioned caulking tools and light sledge hammers of about 4 lbs. in weight, and it is specially directed that each joint maker shall employ a proper striker to assist him in caulking the joint instead of depending on his own blow. After being well and firmly set up, the lead fringe must be pared off, and the joint left neat and even with the socket of the pipe. Sufficient time must be allowed for the lead to cool before the joint is caulked.

6. Turned and Bored Joints—

1st. The planed edges to be painted with red lead.

2nd. The remaining space to be run with lead, and caulked, &c., as with socket pipes.

III.—MASONRY SPECIFICATIONS.

	Page.
XXXI.—Ashlar—Fine	59
XXXII.— „ Rough-tooled	59
XXXIII.— „ Rock	59
XXXIV.— „ Chamfered	60
XXXV.— „ Facing	60
XXXVI.—Block in Course	60
XXXVII.— „ Facing	61
XXXVIII.—Coursed Rubble, 1st Sort	61
XXXIX.— „ „ 2nd Sort...	62
XL.— „ „ 3rd Sort...	63
XLI.—Random Rubble, 1st Sort	63
XLII.— „ „ 2nd Sort...	64
XLIII.—Uncoursed Rubble	64
XLIV.—Stone and Mud	65
XLV.—Dry Stone	65
XLVI.—Retaining Walls	65
XLVII.—Brick-work, 1st Class	66
XLVIII.— „ „ 2nd Class	66
XLIX.—Brick and Mud	66
L.—Brick Nogging	67
Arching.	
LI.—Ashlar	67
LII.—Block in Course	68
LIII.—Rubble	68
LIV.—Brick (Bridges)	68
LV.— „ (Doors, &c.), 1st Class	69
LVI.— „ „ 2nd Class	69
Concrete.	
LVII.—Road Metal	69
LVIII.—Broken Brick	69
LIX.—Cement	69

Ashlar Fine.

Fig. I.
Elevation

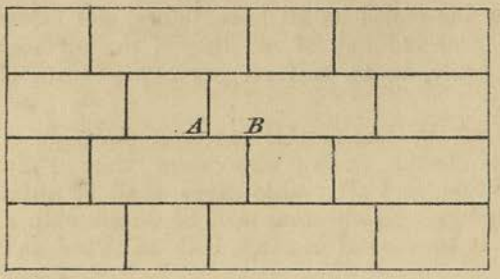


Fig. II.
Section.

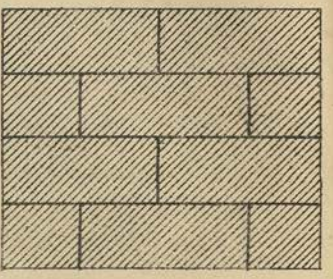


Fig. III.
Plan, 1st Course.

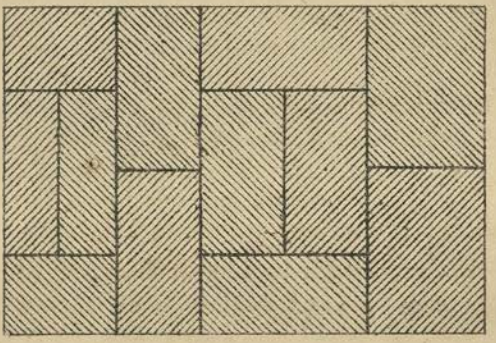
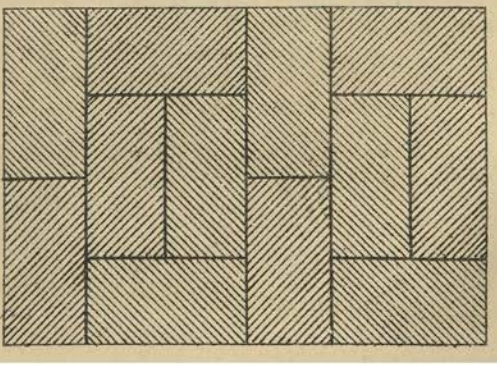


Fig. IV.
Plan, 2nd Course.



III.—MASONRY SPECIFICATIONS.

XXXI.—Ashlar—Fine.

1. Every stone shall be fine-tooled on all beds, joints, and faces, full, true and out of winding if the surfaces are plane, or to uniform curves or twists if required by the design.

Dressing.

2. The stones shall be set in fine mortar (neeroo), the beds or joints being in no case more than $\frac{1}{8}''$ in thickness, and all visible edges shall be quite free from unsightly chippings. Each stone will be struck with a maul, when laid, to bring it to a solid bearing, both as to bed and joint.

Thickness of joints.

3. The stones shall be laid in regular courses not less than 12″ in height, and all courses shall be of the same height, unless otherwise specified, in which case no course shall be thicker than any course below it. No stone shall be less in breadth than in height, or less in length than twice its height.

Size of stones.

4. The face stones shall be laid header and stretcher alternately (unless otherwise ordered). The headers being arranged to come as nearly as possible in the middle of the stretchers above and below, and the stones shall break joint* on the face, or at least half the height of the course, and the bond shall be carefully maintained throughout the wall.

Bond.

5. Through stones.—In walls $2\frac{1}{2}'$ thick and under, the headers shall run right through the wall.

6. The course lines shall be truly horizontal, and side joints vertical throughout.

Courses.

N.B.—This class of work will probably only be required for beds for machinery.

XXXII.—Ashlar Rough-tooled, or Bastard Ashlar.

1. The faces exposed to view shall have a fine dressed chisel draft 1″ wide all round the edges, and be rough-tooled between the drafts, and on all beds and joints, which shall not exceed $\frac{1}{4}''$ in thickness.

2. The stones shall be set in ordinary mortar. In other respects with regard to size of stones, bond, &c., to be precisely the same as in Specification No. XXXI.

XXXIII.—Ashlar, Rock, Rustic or Quarry-faced.

1. Shall be in all respects similar to No. XXXII., except that the exposed faces of the stone between the drafts shall be left rough as the stone comes from the quarry; but no rock face or "bushing" to project more than 3″ from plane of drafts.

* Break of joint means the horizontal distance of the vertical joints of one course from the vertical joints in the courses above and below it: such as A. B., fig. 1.

The drafts may be omitted altogether, except at quoins, if preferred.

XXXIV.—Ashlar—Chamfered.

Shall have the edges round the exposed face of each stone bevelled off to 45° for about depth of 1″ (or more, as may be specified), in all other respects similar to No. XXXIII.

N.B.—Numbers XXXII, XXXIII, XXXIV are suited for solid courses to run right through high piers or at the top of piers or abutments to carry large girders.

XXXV.—Ashlar Facing.

1. The faces of stones shall be rough-tooled, rustic (with or without chisel draft, except at quoins), or chamfered, as specified for the particular work.

Size of stones.

2. In walls built of rubble or concrete and faced with ashlar, the ashlar stones shall be as specified in No. XXXII., except in the matter of dressing the backs of the stones, which may be left rough in the state they leave the quarry.

Dressing beds.

3. But the beds and joints shall be rough-tooled, true and square for at least the same distance in from the face as the thickness of the course in which they occur; *i. e.* if 12″ courses are specified, the beds and joints shall be dressed 12″; if 15″ courses, beds, &c., shall be 15″.

Bond.

4. Bond stones shall run quite through the backing when work is no more than 2½ feet thick, or if more shall overlap at least 6″, and they shall be inserted between 5 and 6 feet apart clear in every course.

How paid for.

5. In work of this sort the face-work alone will be paid for as ashlar, and of those stones only so much as is dressed back, true and square on the beds and joints, ⅓ more being allowed for headers, (*i. e.* in 12″ courses a thickness of 16″ from the face would be paid for as ashlar), the remainder to be paid for according to the character of the backing.

6. The height of the courses should equal an exact number of courses of brick or rubble with intermediate mortar joints, and the backing shall be carried up simultaneously with the face work.

Note.—This class of work is suitable for face of piers and abutments of very large bridges.

XXXVI.—Block in Course.

Differs only from ashlar rough-tooled in the size of the stones. The height of the courses should not be less than 7.″

Note.—Suitable for through courses in piers, abutments of large bridges, or for top courses of same in girder bridges, for verandah pillars, or in large buildings as barracks.

Rock or Rustic Ashlar with Chisel draft.

Fig. I.
Elevation

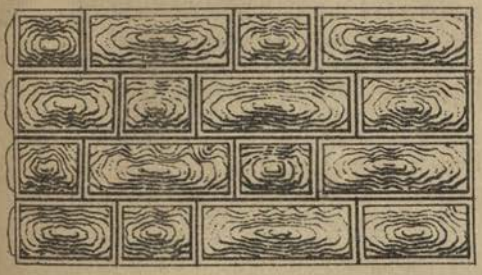
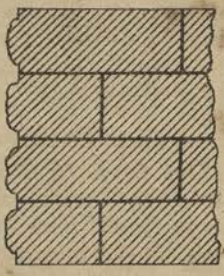


Fig. II.
Section.



Chamfered Ashlar.

Fig. III.
Elevation.

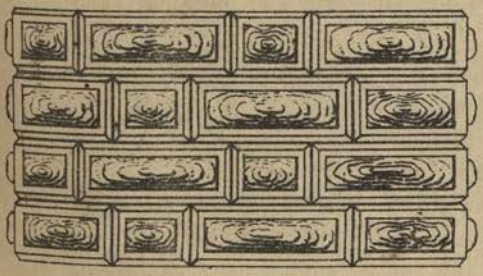
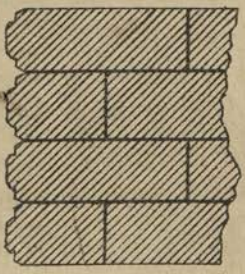
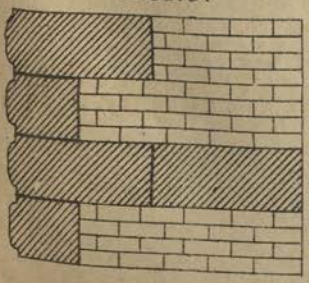


Fig. IV.
Section



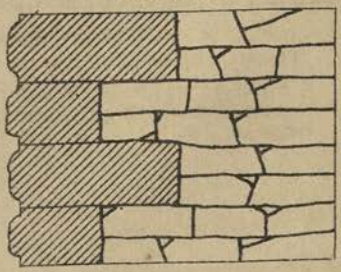
Ashlar facing
to Brick-work.

Fig. V.
Section.



Ashlar facing
to coursed Rubble masonry

Fig. VI.
Section.



Govt. Photozinco. Office, Poona, 1886.

XXXVII.—Block in Course Facing.

1. The height of the courses shall not be less than 7″, and all courses shall be of the same height unless otherwise specified, in which case no course shall be thicker than any course beneath it. No stone shall be less in breadth than in height, or less in length than twice its height. All stones to be set full in mortar.

Size of stones.

Break of joint. 2. Stones shall break joint at least ½ the height of the course.

3. The face of the stones to be left rough (but no projection to exceed 2″) without chisel draft, except at quoins where ½″ draft shall be given.

Face.

4. The joints and beds of all stones to be truly vertical and horizontal, and all stones to be rough-tooled true and square, for at least the same distance in from the face as the thickness of the course in which they occur; *i. e.* in 7″ course, at least 7″ beds, in 9″ course, 9″ beds, and are not to exceed ¼″ in thickness. The back of the stones may be left rough as they come from the quarry.

Joints and beds.

5. At least ⅓ of the stones shall be Headers tailing into the work at least twice their height, and "through" stones shall be inserted 5′ apart which shall run quite through the backing in walls 2½′ thick and under, or if more, a line of headers shall be laid from face to back which shall overlap each other at least 6″.

Headers.

6. The course shall be equal in thickness to an exact number of courses of brick work or rubble, including intermediate joints; and the backing shall be carried up simultaneously with the face work.

7. Only so much of the face stones as is dressed back, full true, and square from face will be paid for as block in course, ⅓ being added for headers. The remainder to be paid for according to the character of the backing.

How paid for.

XXXVIII.—Coursed Rubble, 1st Sort.

1. The stones shall be laid in horizontal courses not less than 7″ in height. All the stones in each course shall be of equal height, and all courses of the same height unless otherwise specified, in which case no course shall be thicker than any course beneath it. All stones to be set full in mortar.

Height of courses.

2. The face stones to be squared on all joints and beds. The beds to be hammer or chisel dressed, true and square, for at least 3″ back from the face,

Dressing.

and the joints for at least 1½″. The face of the stones to be hammer dressed, and "bushing" not to project more than 1½″.

Thickness of joints.

3. No pinnings will be allowed on the face. All side joints shall be vertical and beds horizontal, and no joint shall be more than ⅜″ in thickness.

Size of stones.

4. No face stone shall be less in breadth than its height, or shall tail into the work to a length less than its height, and at least ⅓rd of the stones shall tail into the work at least twice their height, or in thick walls three times their height.

Through stones.

5. Through stones shall be inserted between 5 and 6 feet apart in the clear in every course, and shall run right through the wall when not more than 2′ thick. When the work is more than 2″ thick, a line of two or more headers or stones shall be laid from face to back, which shall overlap each other at least 6″.

Break of joint.

6. Stones shall break joint at least half the height of the course.

Quoins.

7. The quoins, which shall be of the same height as the course in which they occur, shall be formed of header stones at least 1½′ long, laid lengthwise alternately along each face.

Interior face.

8. The work on the interior face shall be precisely the same as on the exterior face, unless the work is to be plastered, in which case the side joints need not be vertical.

Interior of wall.

9. The interior of the wall to consist of flat bedded stones carefully laid on their proper beds and solidly bedded in mortar, chips and spauls of stone being wedged in wherever necessary, so as to avoid thick beds or joints of mortar, care being taken that no dry work or hollow spaces shall be left any where in the masonry. The upper surface of the work shall be brought to an uniform level at the height of every course.

Note.—This class of work is suitable for the larger class of buildings, and for piers and abutments of ordinary bridges.

XXXIX.—Coursed Rubble, 2nd Sort.

Description of work.

1. This description of masonry shall consist of a facing of hammer squared stones on one side, with a backing of rubble masonry built in courses of the same height as the facing, and bonding properly with it. All stones to be carefully set full in mortar.

Face-work.

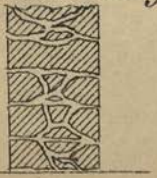
2. The face-work shall be as specified for coursed rubble, 1st sort (Specification No. XXXVIII). The stones in each course *need* not, however, all be of the same height, but not more than two to be used in the height of the course, and the joints may be as much as half an inch in thickness. No course shall be of greater height than any of those below it.

Coursed Rubble, 1st Sort.
Elevation, Fig. I.

Fig. II.
Plan, Course 1.

Fig. III.
Plan, Course 2.

Cross Section, Fig. IV.



Coursed Rubble, 2nd Sort.
Elevation, Fig. V.

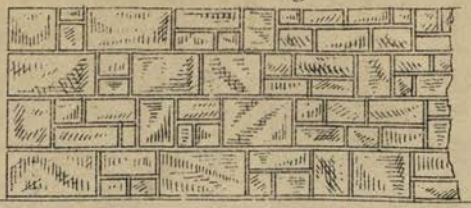


Fig. VI.
Plan, Course 1.

Fig. VII.
Plan, Course 2.

Cross Section, Fig. VIII.

Coursed Rubble, 3rd Sort.
Elevation, Fig. IX.

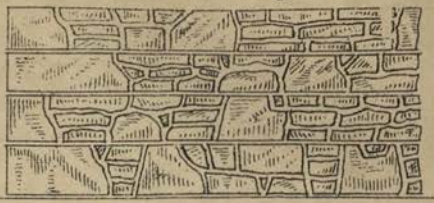


Fig. X.
Plan, Course 1.

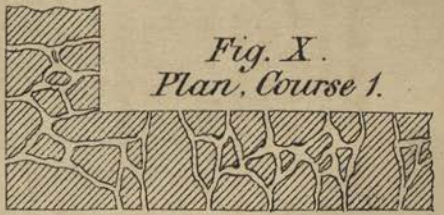


Fig. XI.
Plan, Course 2.

Cross Section, Fig. XII.

3. The hearting or backing shall consist of uncoursed rubble masonry (Specification No. XLIII), which shall be carried up simultaneously with the facing, the face stones being backed as soon as laid, and each course as completed levelled off at top.

Hearting or Backing.

4. In all respects, other than those specified above, the facing and backing shall correspond with Specifications Nos. XXXVIII and XLIII respectively.

XL.—Coursed Rubble, 3rd Sort.

1. In each course, Headers, hammer dressed, of the entire height of the course, are to be placed 5 feet apart, each header to be of a breadth not less than the height, and to tail into the work at least 3 times its height. Between the headers, each course is to be built of smaller stones not less than 2″ thick of which there may be two or three in the height of the course. These stones need not be dressed, but should be as flat bedded as possible; the side joints need not be vertical, but no side joint shall form an angle with a bed joint sharper than 60°. No stone shall be less in breadth or length than its height, and care must be taken to make the stones in the different courses break joint. All stones to be set full in mortar.

Description of work. Headers and Joints.

2. In walls of two feet and under these headers to be through stones. In thicker walls a line of headers to be laid from face to back which shall overlap each other at least six inches. Care should be taken not to place the headers of successive courses above one another.

Through stones.

3. Quoins, &c., as in coursed rubble, 1st sort.

Note.—This class of work is fitted for all minor and subsidiary buildings when the height of the walls is not very great, for enclosure walls, culverts, wing walls, &c.

XLI.—Random Rubble, 1st Sort.

1. The face stones shall be laid absolutely without pinnings on the face. Every stone shall be carefully fitted so as to form neat and close joints, and, if necessary, the edges shall be dressed with a chisel so as to ensure close jointed work. Joints not to exceed ¼″ in thickness.

Fitting.

2. The stones shall be roughly chisel dressed and uniformly coloured and of pretty equal size on the face. They shall be carefully laid and solidly bedded in mortar, and shall tail back and bond well into the backing, and shall not be of greater height than either breadth or face, or length of tail into the work.

Size of stones.

3. One Header or Through stone shall be inserted in at least every square yard of the face, and shall run right through the wall if not more than 2′ thick; if more than 2′ thick, a line of these shall be laid from face to back which shall overlap each other at least 6″.

Through stones.

4. The stones shall be arranged to break joint as much as possible, and long vertical lines of jointing shall be carefully avoided in the facework.

Break of joint.

Quoins.

5. To be same as in Specification No. XLIII, para. 6.

XLII.—Random Rubble, 2nd Sort.

Same as above, but face and joints of stones to be only hammer-dressed, and joints may be ½″ thick.

Note.—Random rubble is most suitable for spandrils of arches.

XLIII.—Uncoursed Rubble.

1. The stones to be set in the work as received from the quarry, and without further dressing of any sort than that of knocking off weak corners and edges with the mason's hammer.

Dressing.

2. The stones shall be carefully laid so as to break joint as much as possible, and solidly bedded with close joints. No joint shall exceed half an inch in thickness. Chips of stone and spauls shall be wedged into the work, wherever necessary, so as to avoid thick beds or joints of mortar. No dry work or hollow spaces shall be allowed in the masonry anywhere; every stone, whether large or small, shall be set flush in mortar, smaller stones used in the filling being carefully selected to fit roughly the interstices between the larger ones.

Bond and laying.

3. The face stones shall be laid, as far as possible, without pinnings in front, and they shall be selected from the mass of quarry stone for greater size, good beds, and uniform colour. They shall be laid, so that they shall tail back and bond well into the work, and shall not be of greater height than either their breadth on face, or length of tail in the work. Fifty per cent. of these stones shall be one cubic foot in content, and twenty-five per cent. shall be headers tailing into the work at least 15 inches.

Face stones.

4. One Header or Through stone shall be provided for every square yard of facing. They shall be at least half a square foot in area of face, and shall run back into the work at least two feet, or be the full depth of the work if it is less than two feet. If the wall be over two feet thick, a line of headers overlapping each other 6 inches shall be laid right through the wall.

Through stones.

5. A fair proportion of the stones used in the hearting shall be of a large size. Thirty per cent. of them shall exceed three quarters of a cubic foot in content.

Size of stones.

6. The quoins, unless otherwise specified, shall be of selected stone, neatly dressed with the hammer or chisel to form the required angle; and laid header and stretcher alternately. No quoin stone shall be less than one cubic foot in content.

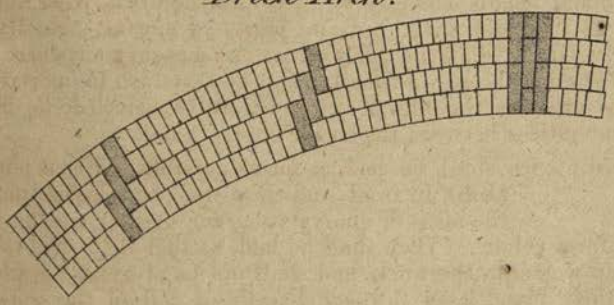
Quoins.

Plate V.

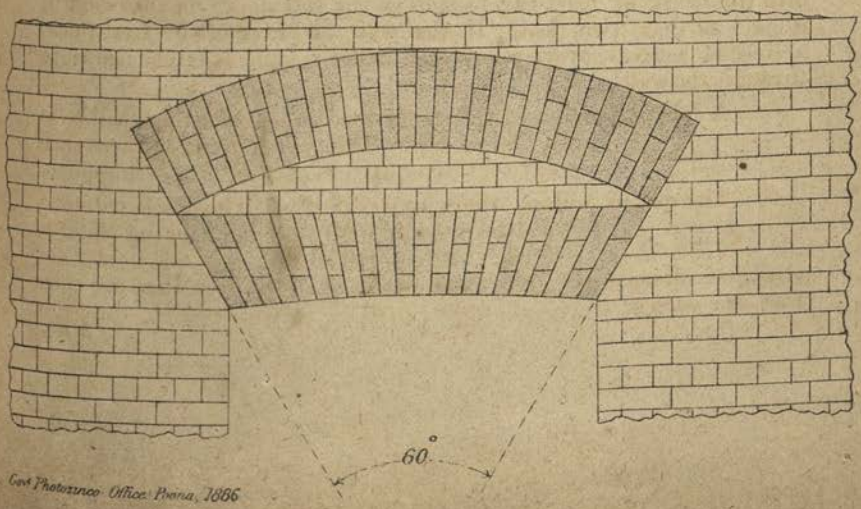
Elevation.
Random Rubble, 1st Sort.

Elevation.
Random Rubble, 2nd Sort.

Brick Arch.



Flat and Relieving Arches.



Govt Photozinco Office Poona, 1886

7. The exposed face of the work shall be carefully and neatly pointed with mortar in all joints, and round each stone, large and small. The joints shall be raked out carefully at least one inch, and wetted and pointed with good fresh mortar carefully inserted, and the joints neatly finished off with the trowel. At the back of the work the joints shall be finished off by being neatly struck and smoothed off with the trowel while the mortar is fresh.

Pointing.

XLIV.—Stone and Mud Masonry.

1. Shall be of the class and character of masonry designated above coursed rubble 3rd sort (Specification No. XL), except that mud is used instead of mortar.

Description of work.

2. The mud used for this purpose shall be prepared from carefully selected earth of a tenacious nature, which, when dry, will form a kind of cement. The earth to be well tempered by men's feet, and worked down with water until it is perfectly free from lumps, and of the consistence of thick paste. Sand and chopped straw to be added in such proportions as the officer in charge of the work may direct.

Mud mortar.

Note.—When this description of masonry is used for supports of centerings, thin timber ties should be inserted at every three feet, to bind the faces of the wall together. This object is equally gained by building brushwood or split bamboos between the courses. At the ends of the walls the brushwood should be laid so as to cross the face layers.

XLV.—Dry Stone Masonry.

1. Similar in all respects to coursed rubble 3rd sort (Specification No. XL), except that the stones shall be laid dry without mortar of any kind.

XLVI.—Dry Rubble Retaining Walls.

1. These walls to be built of dry rubble stone masonry in courses of from 8 to 20 inches in height, and when not exceeding 30 feet in height to have a section of at least 3 feet width at top, to be perpendicular at back, and to have a batter in front of 1 in 4.

Section of wall.

2. The foundations if in moorum to be carried down to a depth of from 2 to 3 feet below the hill slope at the outer side, and to be filled in with the largest blocks of stone procurable within a moderate distance, carefully laid and packed in by hand with stones of a smaller size.

Foundations.

3. The beds of the stones to be laid at right angles to the face batter. Each course to be built through the wall with proper bond in respect to itself and the course below. The front and rear faces of the wall to be built precisely similar in all respects, and to be equally bonded with the interior of the work.

Superstructure.

4. Through stones or headers, at least 3 feet in length, to be provided in each course at intervals of from 5 to 6 feet apart on the face of the work,

Through stones.

and continued throughout its whole width, each header overlapping the one in front by 9 inches so as to tie the front and rear faces of the work together. These bond stones shall be of the full height of the headers in the facing, as broad at least as they are high, and of the greatest length readily procurable beyond 3 feet.

Stones.

5. The stones used to be of the largest and best description procurable within a moderate distance, and to be roughly hammer dressed so as to secure as large bedding surfaces as possible. When laid, all hollows round them to be tightly packed by hand and hammer with smaller stones.

Filling behind wall.

6. The filling immediately behind the wall to consist, as far as possible, of stone refuse and chips. Earth not to be used for this purpose if it can be avoided.

Note.—In masonry by "hammer dressed" is understood dressed with the "sootkie" or Deccan masons' hammer.

XLVII.—Brick-work, 1st Class.

Size moulding.

1. The bricks to be of uniform size ($9'' \times 4\frac{1}{2}'' \times 2\frac{1}{2}''$, unless otherwise specified), thoroughly well burnt and sound, ringing clearly, and moulded on tables with sand, soorkhee, or water, as may be ordered by the Executive Engineer.

Bond.

2. The bricks are to be laid flush in mortar in such bond as the Executive Engineer may direct, and every course must be thoroughly grouted, and the whole executed in a good and workmanlike manner.

Colour.

3. As far as practicable, bricks of a uniform colour are to be selected for the face-work when it is not to be plastered.

Joints.

4. The bed-joints are not to exceed $\frac{3}{8}''$ in thickness, *i. e.* with bricks $2\frac{1}{2}''$ thick; 4 courses, including mortar joints, are not to exceed $11\frac{1}{2}''$ in height.

Soaking.

5. The bricks to be soaked for at least 12 hours before they are put into the work.

Bats.

6. No bats or half bricks to be used in the work, unless absolutely necessary as closers.

XLVIII.—Brick-work, 2nd Class.

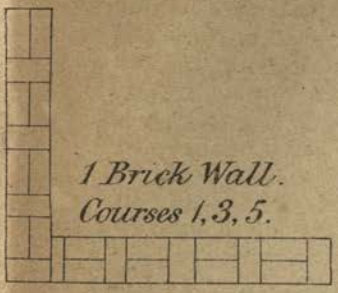
Same as above, but bricks may be moulded on the ground, joints to be not more than $\frac{1}{2}''$ thick (or 4 courses not to exceed 1′ in height if bricks are of English pattern.)

XLIX.—Brick and Mud work.

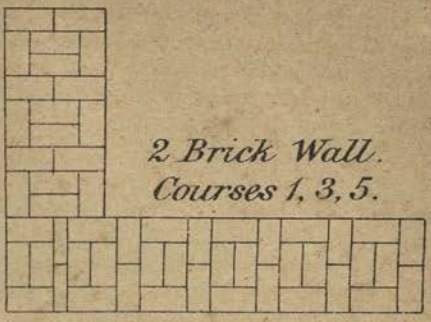
Bricks as in 2nd class, but laid in mud, made of earth, approved by the Executive Engineer, which is to be well tempered and worked down with water till it is perfectly free from lumps and of the consistency of stiff paste. To be mixed with chopped grass or sand, if necessary, in such proportions as may be directed.

Flemish Bond

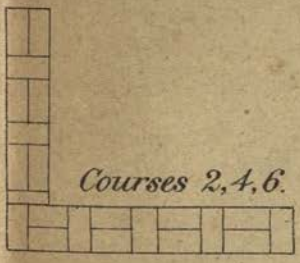
Plate VI.



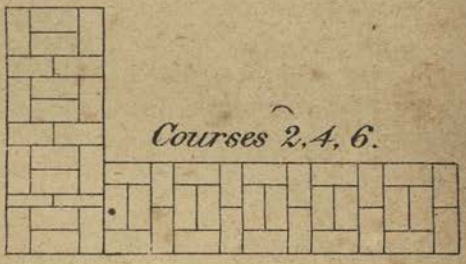
1 Brick Wall.
Courses 1, 3, 5.



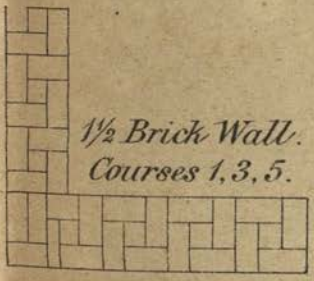
2 Brick Wall.
Courses 1, 3, 5.



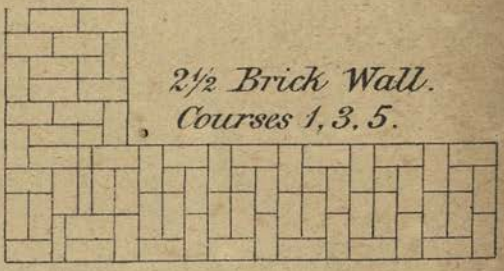
Courses 2, 4, 6.



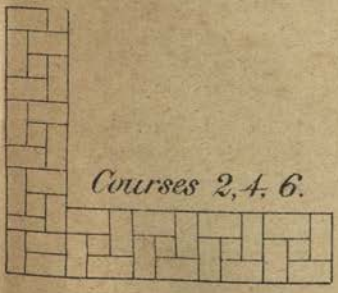
Courses 2, 4, 6.



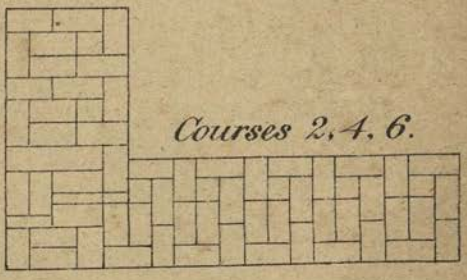
1½ Brick Wall.
Courses 1, 3, 5.



2½ Brick Wall.
Courses 1, 3, 5.



Courses 2, 4, 6.



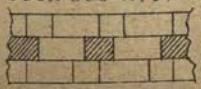
Courses 2, 4, 6.

Hollow Walls with common bricks

1st Method.

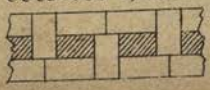
Courses 1, 3, 5.

Courses 2, 4, 6.

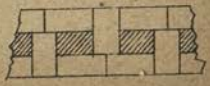


2nd Method

Courses 1, 3, 5.



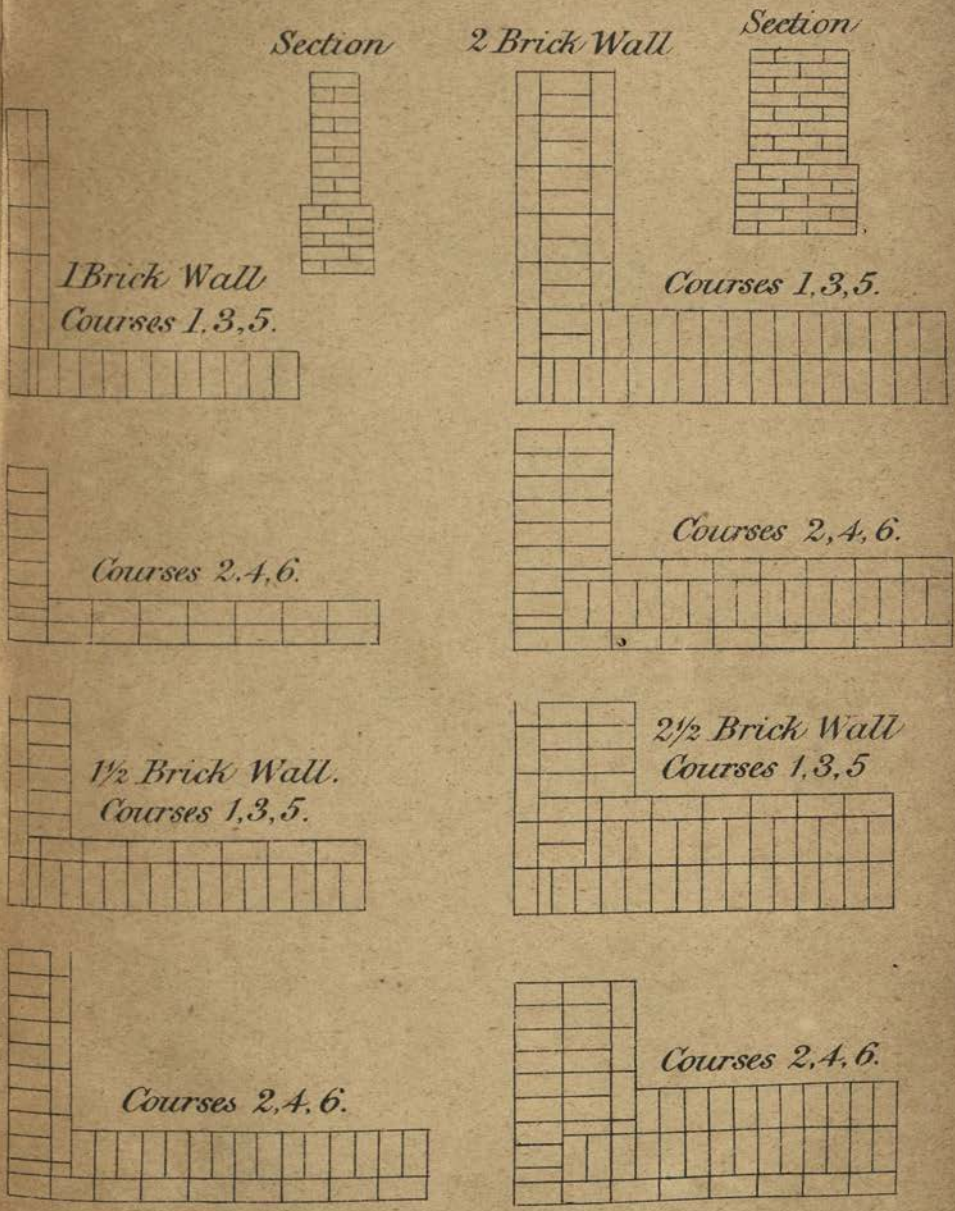
Courses 2, 4, 6.



Govt. Photozinco Office, Poona. 1887.

Brick Work
English Bond.

Plate VII.



Jno.ᵈ Photozinco Office, Poona, 1887

L.—Brick Nogging.

Description of work.

1. This description of work, which will be 6 inches only in thickness, will consist of a combination of teak posts and planking, the interspaces being filled in with brick-work, 1st class (Specification No. XLVII), and finally plastered with lime on both faces.

Network of Timber.

2. The uprights or posts will measure $6'' \times 5''$ and be placed at central distances of 5 feet apart. Between these posts and notched into them there will be horizontal ribs of teak planking $6'' \times 2''$ fixed at 3 feet vertical distances apart. Between these latter, cross braces or diagonals $6'' \times 1\frac{1}{2}''$ will be inserted, halved together at points of intersection and spiked to the posts.

Interspaces.

3. All interspaces will then be filled in with brick and lime masonry, built up flush with the outer faces of the timber framework. Bricks to be of same breadth as thickness of post.

Plastering.

4. After the completion of the walling the surfaces of the work to be thoroughly wetted and nails driven into the timber framework to give a hold to the mortar plaster with which both faces of the work should then be finished off.

ARCHING SPECIFICATIONS.

LI.—Ashlar Arching.

1. The arch stones shall be dressed full and true to their proper shapes with the necessary summering, twist, or winding, and shall be carefully set in good fine mortar.

Dressing beds.

2. The intrados, joints and beds to be fairtooled, and all horizontal joints across the intrados to have a $\frac{3}{4}''$ chamfer to prevent the arises chipping.

Face stone.

3. The face stones may be tooled, or rockfaced, with or without chamfer, as may be specified.

Size of stones.

4. The arch stones shall not be less than 10″ on their least dimension, and shall break joint at least 9″. In archings up to 2′ in thickness, the stones shall all be of the full thickness of the ring. In arches from 2′ to 3′ in thickness, the stones shall be laid header and stretcher alternately, all the headers being of the full depth of the ring and not more than two stretchers going to make up thickness of ring.

In arches over 3′ in depth the quoins and key stones alone need be of the full thickness of the ring. The stones when laid double, as above, to form the ring, shall be laid in such bond as may be directed.

Exact uniformity will be required in the thickness of each course of arch stones, and in oblique or skew arches great care is to be taken to dress the beds to the required winding.

5. The bed joint shall be perpendicular to the tangent of the curve of the arch at each point, and the side joints shall be at right angles to the face and bed joints, and the thickness of the joints shall not exceed $\frac{3}{16}''$.

Joints.

6. The mortar of the joints on face and soffit of arch to be raked out when centering is removed, and neatly pointed with good mortar or cement.

Note.—Suitable for bridges over 60′ span.

LII.—Block in Course Arching.

1. Shall be precisely similar to the above, except that the stones shall not be less than 6″, on their least dimension, and shall not break joint less than 6″, and shall only be rough-tooled on beds and joints, which shall not exceed $\frac{1}{4}''$ in thickness.

Note.—Suitable for bridges from 30′ to 60′ for verandah arches in barracks, &c. &c.

LIII.—Rubble Arching.

1. Shall consist of flat bedded hammer dressed slabs laid solidly and flush in mortar with their beds perpendicular to tangent to the curve of the arch, and shall properly break joint and bond with each other.

2. The joints on face and soffit shall not exceed $\frac{3}{8}''$ in thickness. The backs of the stones when open shall be solidly wedged up with spauls and chips of stone set in mortar.

Joints.

3. The arch quoins to be of the same thickness as the sheeting of the course, but they shall be superior selected stones, in all cases extending right through from intrados to extrados, and alternately, not less than 15″ and 21″ long, upon the intrados or bed face.

Quoins.

4. No arch stone in the sheeting shall be less than 3″ on its least dimension, and the stones shall break joint with each other at least 6″. In arch rings 15″ thick and under, all stones shall be of the full thickness of the ring.

Size of arch stones.

In arch rings more than 15″ thick, the stones will be laid in alternate courses of headers and stretchers, unless otherwise specified ; not more than two stones going to make up the thickness of the arch ring.

Bond.

The joints on face and soffit to be raked out when the centering is removed, and neatly pointed with good mortar or cement.

Note.—Suitable for arches up to 30′ span.

LIV.—Brick Arching for Bridges.

1. The bricks to be, as in 1st class brickwork, laid in concentric half brick rings.

Half brick rings.

Joints. 2. The voussoir joints are to be properly summered, and not to exceed $\frac{2}{3}$″ in thickness.

Skew backs. 3. Bricks forming skew back-joints are to be moulded or cut so as to radiate truly.

Bond of rings. 4. Great care to be taken that the rings are bonded together properly, whenever the joints of any of the rings come to a summering, or plane face.

LV. and LVI.—Brick Arching over doors and windows.

As above, but bricks as in 2nd class brick-work and joints not to exceed $\frac{1}{2}$″.

CONCRETE SPECIFICATIONS.

LVII.—Concrete of Shingle or Road Metal.

Proportion. 1. Shall consist (unless otherwise specified) of—

Slaked lime	...	...	1 part.
Clean sharp sand	...	...	2 parts.
Screened shingle	...	...	5 ,,

Note.—If shingle is not obtainable, 3 or 4 parts of road metal, $1\frac{1}{2}$″ gauge, may be used instead.

Mixing. 2. The lime and sand to be made into mortar in the usual manner, and then thoroughly incorporated with the shingle (or metal), adding, if required, a little water as in No. LIX.

Layers. 3. The concrete shall be laid in the work in layers not exceeding 9″ in depth, and shall be well rammed with heavy wooden or iron rammers.

Grouting. 4. If the lime does not fill all the spaces between the stones and cream to the surface, the top of each layer is to be grouted with thin mortar before the next layer is laid.

LVIII.—Concrete of broken brick and kunker.

Proportion. 1. Shall consist (unless otherwise specified) of—

Lime slaked	...	...	1 part.
Kunkur chunam	...	...	2 parts
Clean sharp sand	...	...	1 part.
Broken bricks	...	...	2 parts.

General. 2. In all other respects as regards mixing, depth of layers and grouting to be as in Specification No. LVII. above.

LIX.—Cement Concrete.

1. Portland Cement	...	...	1 part.
Sand	...	...	2 parts.
Screened shingle	...	...	5 ,,

Note.—4 parts of road metal, $1\frac{1}{4}$″ gauge, may be substituted for shingle.

2. To be mixed dry immediately before use. When thoroughly mixed, water to be added through the rose of a watering pot only in such quantity as to ensure its thoroughly setting. The volume of water required will probably be about ½ the volume of the cement.

Mixing.

3. The concrete must be used within three hours of its being wetted. If to be kept more than three hours after being mixed, great care shall be taken that the sand and shingle are thoroughly dried before-hand, and that no water or wet reaches it.

Keeping.

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATIONS.

XXXI.—Ashlar—Fine.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stone, Rough, 12″ thick, averaging 4½ C. F. each ... C. F.	100	0 6 C. F.	37 8			
Lime, slaked C. F.	8	12 0 40 C. F.	2 6			
Sand, fine ... C. F.	8	2 0 100 C. F.	0 3			
Charcoal ... lbs.	120	1 0 80 lbs.	1 8			
Iron, &c. .. lbs.	8	1 0 8 lbs.	1 0			
Sundries	...	... ...	1 0			
		Total Materials.	43 9			
Labour.						
Masons, 1st Class, for dressing .	44	0 12 each.	33 0			
Do. do. setting...	12	0 12 do.	9 0			
Nowgunnies	12	0 5 do.	3 12			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	¼	0 8 do.	0 2			
Smiths...	2	0 12 do.	1 8			
Bellows-boys	2	0 4 do.	0 8			
Grinding chunam C. F.	10	4 0 100 C. F.	0 6			
Scaffolding	...	... ...	2 0			
Sundries	...	... ...	1 0			
		Total Labour...	52 6			
		Total for 100 C. F. ...	95 15		Total for 100 C. F.	

N. B.—If thicker courses were used, the stone will cost more, say about 8 annas per foot for 15″ courses, 10 annas a foot for 18″ courses, &c.

In using thicker courses of larger stones, the surface to be dressed will be less, but the extra cost of handling larger stones will be more, so that no reduction can be made in cost of labour. This above applies to the harder description of Poona stone.

If of basalt, such as in Bombay, Nowrojee Hill, half as much more labour will be required for dressing.

XXXII.—Ashlar Rough-tooled.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a Per	Rs. a.
Stones, Rough, 12″ thick averaging 4½ C. F. each ... C. F.	100	0 6 C. F.	37 8			
Lime, slaked... C. F.	12	12 0 40 C. F.	3 10			
Sand ... ... C. F.	18	2 0 100 C. F.	0 6			
Charcoal ... lbs.	90	1 8 80 lbs.	1 2			
Iron ... ... lbs.	4	1 0 8 lbs.	0 8			
Sundries	...	... ...	1 0			
Labour.		Total Materials.	44 2			
Masons, 1st Class, for dressing...	25	0 12 each	18 12			
Do. for setting ...	12	0 12 do.	9 0			
Nowgunnies	12	0 5 do.	3 12			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	¼	0 8 do.	0 2			
Smiths...	1½	0 12 do.	1 2			
Bellows-boys	1½	0 4 do.	0 6			
Grinding chunam C. F.	18	3 0 100 C. F.	0 8			
Scaffolding	...	... ...	2 0			
Sundries	...	... ...	1 0			
		Total Labour...	37 12			
Total for 100 C. F. ...			81 14	Total for 100 C. F. ...		

N.B.—The same remarks as for Ashlar fine are applicable to this.

XXXIII.—Ashlar, Rock, Rustic or Quarry-faced.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Same as above	...	... ...	44 2			
Labour.						
Masons, 1st Class, for dressing	22	0 12 each.	16 8			
Rest same as above	...	... ...	19 0			
		Total Labour...	35 8			
Total for 100 C. F. ...			79 10	Total for 100 C. F....		

N.B.—The same remarks as for Ashlar fine are applicable to this.

XXXIV.—Ashlar—Chamfered.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Same as for Ashlar rough-tooled ...	...	... ...	44 2			
Labour.						
Masons for dressing ...	27	0 12 each.	20 4			
Rest same as for Rustic Ashlar	...	... ...	19 0			
		Total Labour...	39 4			
Total for 100 C. F. ...			83 6	Total for 100 C. F....		

N.B.—The same remarks as for Ashlar fine are applicable to this.

XXXV.—Ashlar Facing.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stones, Rough, 12" thick, averaging 4 C. F. each ... C. F.	125	0 5 C. F.	39 1			
Lime, slaked C. F.	16	12 0 40 C. F.	4 13			
Sand... ... C. F.	24	2 0 100 C. F.	0 8			
Charcoal ... lbs.	60	1 0 80 lbs.	0 12			
Iron ... ... lbs.	3	1 0 8 lbs.	0 6			
Sundries	...	... ...	1 0			
		Total Materials .	46 8			
Labour.						
Masons, for dressing ...	15	0 12 each.	11 4			
Do. setting ...	10	0 12 do.	7 8			
Nowgunnies	12	0 5 do.	3 12			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Smiths...	1	0 12 do.	0 12			
Bellows-boys	1	0 4 do.	0 4			
Grinding chunam C. F.	24	3 0 100 C. F.	0 11			
Scaffolding	...	... ...	2 0			
Sundries	...	... ...	1 0			
		Total Labour ...	28 0			
		Total for 100 C. F. ...	75 1		Total for 100 C. F....	

N.B.—The same remarks as for Ashlar fine are applicable to this.
Bond stones through the backing should be calculated separatly or in the backing.

XXXV. (*a*).—Ashlar Facing rustic with chisel draft.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Same as for Ashlar facing rough-tooled ...	...	... ...	46 8			
Labour.						
Masons for dressing ...	12	0 12 each.	9 0			
Rest same as for Ashlar facing rough-tooled .	...	... ...	17 5			
		Total Labour ...	26 5			
Total for 100 C. F. ...			72 13	Total for 100 C. F....		

N. B.—The same remarks as for Ashlar facing rough-tooled are applicable to this.

XXXV. (*b*).—Ashlar Facing chamfered.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Same as for Ashlar facing rough-tooled .	...	... ...	46 8			
Labour.						
Masons for dressing ...	17	0 12 each.	12 12			
Rest same as for Ashlar facing rough-tooled .	...	... ...	17 5			
		Total Labour ...	30 1			
Total for 100 C. F. ...			76 9	Total for 100 C. F....		

XXXVI.—Block in Course.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stone, Rough, 9″ high C.F.	100	0 4 foot	25 0			
Lime, slaked C.F.	13	12 0 40 C.F.	3 14			
Sand ... C.F.	20	2 0 100 C.F.	0 6			
Charcoal ... lbs.	90	1 0 80 lbs.	1 2			
Iron ... lbs.	4	1 0 8 lbs.	0 8			
Sundries	...	... ...	1 0			
		Total Materials.	31 14			
Labour.						
Same as for Ashlar rough-tooled ...	...	... ...	37 12			
Total for 100 C.F. ...			69 10	Total for 100 C. F....		

XXXVII.—Block in Course Facing.

c

Artificers, Labourers, and Materials for 100 Cubic Foot.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stone, Rough, about 1¼ C. F. each, and 9″ high...	125	20 0 100 C.F.	25 0			
Rest same as for Ashlar Facing rough-tooled.	...	... ...	7 7			
		Total Materials.	32 7			
Labour.						
Same as for Ashlar facing rough-tooled .	...	... ...	28 9			
Total for 100 C. F. ...			61 0	Total for 100 C.F....		

XXXVIII.—Coursed Rubble, 1st Sort.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.				Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.		Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Headers or through stones ... ...No.	35	9	0	100	No.	3	8						
Face stones ...No.	284	4	0	100	No.	11	6						
Rubble stone, large C.F.	17	4	0	100	C. F.	0	11						
Lime, slaked ...C.F.	14	12	0	40	C. F.	4	3						
Sand ... ...C.F.	21	2	0	100	C. F.	0	7						
Sundries	...	...		...		0	12						
		Total Materials.				20	15						
Labour.													
Masons, 2nd Class, for dressing ...	6	0	10		each.	3	12						
Do. 2nd Class, for setting	5	0	10		do.	3	2						
Coolies	5	0	3		do.	0	15						
Women	5	0	2		do.	0	10						
Grinding chunam C.F.	21	3	0	100	C. F.	0	10						
Bhisties	½	0	8		each.	0	4						
Smiths...	¼	0	12		do.	0	3						
Bellows-boys	¼	0	4		do.	0	1						
Scaffolding	...		...		...	1	0						
Sundries	...		...		...	0	12						
		Total Labour...				11	5						
Total for 100 C.F. ...						32	4	Total for 100 C.F....					

Note.—The above rate applies to walls 18" thick.

XXXIX.—Coursed Rubble, 2nd Sort.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Headers or through stones ... ...No.	35	9 0 100 No.	3 8			
Face stones ...No.	142	4 0 100 No.	5 11			
Rubble stone, large C.F.	50	5 0 100 C. F.	2 8			
Lime, slaked ...C.F.	16	12 0 40 C.F.	4 13			
Sand ... ...C.F.	24	2 0 100 C.F.	0 8			
Sundries		... ...	0 10			
		Total Materials.	17 10			
Labour.						
Masons, 2nd Class, for dressing	3	0 10 each.	1 14			
Masons, 2nd Class, for setting	5	0 10 do.	3 2			
Coolies...	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Grinding chunam C. F.	24	3 0 100 C. F.	0 12			
Bhisties	½	0 8 each	0 4			
Smiths...	⅙	0 12 do.	0 1			
Bellow-boys	⅛	0 4 do.	0 1			
Scaffolding	..	... ...	1 0			
Sundries	...	... ...	0 10			
		Total Labour...	9 5			
		Total for 100 C. F. ...	26 15		Total for 100 C.F. ...	

Note.—The above rate applies to walls 18" thick.

XL.—Coursed Rubble, 3rd Sort.

Artificers, Labourers, and Materials for 100 Cubic feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Headers or through stones ... ...No.	25	9 0 100 No.	2 4			
Rubble stone C.F.	100	4 0 100 C.F.	4 0			
Lime ... C.F.	20	12 0 40 C.F.	6 0			
Sand ... C.F.	30	2 0 100 C.F.	0 10			
Sundries	...	... ...	0 8			
		Total Materials.	13 6			
Labour.						
Masons for setting, 2nd Class	5	0 10 each.	3 2			
Coolies	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Grinding chunam C.F.	30	3 0 100 C.F.	0 14			
Bhisties	½	0 8 each.	0 4			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 8			
		Total Labour...	7 5			
		Total for 100 C.F. ...	20 11		Total for 100 C.F....	

Note.—The above rate applies to walls 18" thick.

XLI.—Random Rubble, 1st Sort.

Artificers, Labourers, and Materials for 100 Cubic feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Quoins ... ...No.	4	0 7 each	1 12			
Headers or through stones ... ...No.	35	9 0 100 No.	3 8			
Rubble stone C.F.	120	4 0 100 C.F.	4 13			
Lime, slaked C.F	14	12 0 40 C.F.	4 3			
Sand ... C.F.	21	2 0 100 C.F.	0 7			
Charcoal ... lbs.	20	1 0 80 lbs.	0 4			
Sundries	...	.....	0 12			
		Total Materials.	15 11			
Labour.						
Masons, 2nd Class ...	16	0 10 each	10 0			
Coolies	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Bhisties	¼	0 8 do.	0 2			
Smiths	½	0 12 do.	0 6			
Bellows-boys ...	½	0 4 do.	0 2			
Grinding chunam C.F.	21	3 0 100 C.F.	0 10			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 12			
		Total Labour...	14 9			
		Total for 100 C.F. ...	30 4		Total for 100 C.F....	

XLII.—Random Rubble, 2nd Sort.

May be taken as much as coursed rubble, 2nd sort.

XLIII.—Uncoursed Rubble.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Headers or through stones ... ...No.	20	9 0 100	1 13			
Rubble stone, large C.F.	50	5 0 100	2 8			
Do. small C.F.	70	3 0 100	2 2			
Lime, slaked C.F.	20	12 0 40	6 0			
Sand ... C.F.	30	2 0 100	0 10			
Sundries	...	.....	0 8			
		Total Materials.	13 9			
Labour.						
Masons, 2nd Class No.	4	0 10 each	2 8			
Coolies ... No.	4	0 3 do.	0 12			
Women ... No.	2	0 2 do.	0 4			
Grinding chunam C.F.	30	3 0 100	0 14			
Bhisties ... No.	½	0 8 each	0 4			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 8			
		Total Labour...	6 2			
		Total for 100 C.F. ...	19 11		Total for 100 C.F....	

XLIV.—Stone and Mud Masonry.

Materials and Labour.		No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
			Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Materials.													
Headers	No.	25	8	0	100	2	0						
Rubble stone ...	C.F.	100	4	0	100	4	0						
Earth	C.F.	24	2	8	100	0	10						
Sand	C.F.	12	2	0	100	0	4						
Sundries		...		.....		0	6						
			Total Materials.			7	4						
Labour.													
Masons, 2nd Class	No.	2	0	10	each	1	4						
Coolies	No.	2	0	3	do.	0	6						
Women	No.	1	0	2	do.	0	2						
Bhisties	No.	¼	0	8	do.	0	2						
Sundries		...		.....		0	6						
			Total Labour...			2	4						
		Total for 100 C F. ...				9	8	Total for 100 C.F.					

XLV.—Dry Stone Masonry.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Headers or through stones ... ... No.	25	8 0 100	2 0			
Rubble stone ...C. F.	125	5 0 100	6 4			
Sundries	...	.....	0 8			
		Total Materials.	8 12			
Labour.						
Masons, 2nd Class No.	3	0 10 each.	1 14			
Coolies ... ... No.	1	0 3 do.	0 3			
Women ... ... No.	2	0 2 do.	0 4			
Sundries	...	.....	0 9			
		Total Labour...	2 14			
		Total for 100 C. F. ...	11 10		Total for 100 C.F.	

XLVI.—Dry Rubble Retaining Walls.

Materials and Labour.		No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
			Rs.	a.	Per	Rs.	a		Rs.	a.	Per	Rs.	a.
Materials.													
Headers or through stones	No.	40	9	0	100	3	10						
Rubble stone ...	C. F.	120	3	0	100	3	10						
Gunpowder ...	Lbs.	8	0	3	lb.	1	8						
Sundries		...		.....		0	4						
			Total Materials			9	0						
Labour.													
Masons, 2nd Class	No.	4	0	10	each.	2	8						
Coolies	No.	4	0	3	do.	0	12						
Smiths	No.	c ½	0	12	do.	0	6						
Sundries		...		.....		0	4						
			Total Labour...			3	14						
	Total for 100 C. F. ...					12	14	Total for 100 C.F.					

Note.—The above rate is for walls not exceeding 30 feet in height.

XLVII.—Brick-work, 1st Class.

Artificers, Labourers, and Materials for 100 Cubic feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks, $9'' \times 4\frac{1}{4}'' \times 2\frac{1}{2}''$, allowing 5 per cent. for wastage ... No.	1520	12 0 1,000	18 4			
Lime, slaked ... C. F.	16	12 0 40 C. F.	4 13			
Sand ... ... C. F.	24	2 0 100 C. F.	0 8			
Sundries	...	.....	0 6			
		Total Materials	23 15			
Labour.						
Bricklayers ... No.	6	0 10 each.	3 12			
Coolies ... ... No.	2	0 3 do.	0 6			
Women ... ... No.	6	0 2 do.	0 12			
Bhisties ... ... No.	$\frac{1}{2}$	0 8 do.	0 4			
Grinding chunam. C. F.	24	3 0 100 C.F.	0 11			
Sundries	...	.....	0 6			
Scaffolding up to 12 ft. in height	...	.....	1 0			
		Total Labour...	7 3			
Total for 100 C. F. when the wall is 12 feet in height.			31 2		Total for 100 C.F. when the wall is 12 feet in height.	

N.B.—When the wall is higher, add for every additional 5 feet in height annas eight per 100 C. F. to the whole cost; thus rate—

	Rs. a.
For 12 feet	31 2
For 17 feet	31 10
For 22 feet	32 2

and so on.

LXVIII.—Brick-work, 2nd Class.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks, 9″ × 4¼″ × 2½″, allowing 5 per cent for wastage	1,410	8 0 1,000	11 4			
Lime, slaked	20	12 0 40 C. F.	6 0			
Sand	30	2 0 100 C. F.	0 10			
Sundries	...	.....	0 6			
		Total Materials.	18 4			
Labour.						
Bricklayers	4	0 10 each.	2 8			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Grinding chunam C. F....	30	3 0 100 C. F.	0 14			
Scaffolding	...	.....	1 0			
Sundries...	...	.....	0 6			
		Total Labour...	6 2			
		Total for 100 C. F. ...	24 6		Total for 100 C.F.	

N.B.—The remark as for Brick-work, 1st Class, page 85, is applicable to this.

XLIX.—Brick and Mud Work.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks 9″×4¼″×2½″ allowing 5 per cent. for wastage	1,300	8 0 1,000 No.	10 6			
Mud ... ... C.F.	30	1 8 100 C.F.	0 7			
Sundries	...	.....	0 3			
		Total Materials.	11 0			
Labour.						
Bricklayers ... No.	4	0 10 each.	2 8			
Coolies	3	0 3 do.	0 9			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Sundries	...	.....	0 3			
Scaffolding	...	.....	1 0			
		Total Labour...	5 4			
		Total for 100 C. F. ...	16 4		Total for 100 C.F.	

L.—Brick Nogging.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	7·16	3 0 C.F.	21 8			
Nails, &c.	...	.....	0 8			
Burnt brick masonry, 2nd class ... C.F.	30	24 6 100	7 5			
Sundries	...	.....	0 4			
		Total Materials.	29 9			
Labour.						
On wrought timber. C.F.	7·16	0 6 C.F.	2 11			
Sundries	...	.....	0 4			
		Total Labour...	2 15			
Add.						
Plastering both sides. S.F.	120	7 7 100	8 15			
		Total for 60 S.F.	41 7			
		Total for 100 S.F. ...	69 1		Total for 100 S.F.	

LI.—Ashlar Arching.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stones, rough, averaging $4\frac{1}{5}$ C. F. each C.F.	100	0 6 foot	37 8			
Lime, slaked .. C.F.	10	12 0 40 C. F.	3 0			
Sand ... ... C.F.	10	2 0 100 C. F.	0 3			
Charcoal ... ... Lbs.	140	1 0 80 lbs.	1 12			
Iron ... ... Lbs.	8	1 0 8 lbs.	1 0			
Sundries	...	.....	1 0			
		Total Materials.	44 7			
Labour.						
Masons for dressing (1st class), 2 Masons for a stone	48	0 12 each.	36 0			
Do. for setting... ...	12	0 12 do.	9 0			
Nowgunnies	12	0 5 do.	3 12			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	$\frac{1}{4}$	0 8 do.	0 2			
Smiths	$2\frac{1}{2}$	0 12 do.	1 14			
Bellows-boys	$2\frac{1}{2}$	0 4 do.	0 10			
Grinding chunam C.F.	10	4 0 100 C.F.	0 6			
Scaffolding	...	.....	2 0			
Sundries...	...	.....	1 0			
		Total Labour...	55 14			
		Total for 100 C.F. ...	100 5			Total for 100 C.F.

LII.—Block in Course Arching.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.				Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.		Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Materials.													
Stones, rough ...C. F.	100	0	4		foot.	25	0						
Lime, slaked ...C. F.	13	12	0	40	C. F.	3	14						
Sand ... ...C. F.	20	2	0	100	C. F.	0	6						
Charcoal ... ... Lbs.	90	1	0	80	lbs.	1	2						
Iron ... ... Lbs.	4	1	0	8	lbs.	0	8						
Sundries	...			.....		1	0						
		Total Materials.				31	14						
Labour.													
Masons for dressing ...	25	0	12		each.	18	12						
Do. for setting ...	12	0	12		do.	9	0						
Nowgunnies	12	0	5		do.	3	12						
Coolies	2	0	3		do.	0	6						
Women	6	0	2		do.	0	12						
Bhisties	¼	0	8		do.	0	2						
Smiths...	1½	0	12		do.	1	2						
Bellows-boys	1½	0	4		do.	0	6						
Grinding chunam C. F.	20	3	0	100	C. F.	0	10						
Scaffolding	...			.....		2	0						
Sundries	...			.....		1	0						
		Total Labour...				37	14						
Total for 100 C.F. ...						69	12	Total for 100 C. F.					

LIII.—Rubble Arching.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Slabs, rough, abont $1\frac{1}{2}' \times 1' \times \frac{1}{2}'$ each C.F.	100	12 8 100 C. F.	12 8			
Lime, slaked ...C. F.	16	12 0 40 C. F.	4 13			
Sand ...C. F.	24	2 0 100 C. F.	0 8			
Charcoal ... lbs.	30	1 0 80 lbs.	0 6			
Sundries	...	... ...	0 12			
		Total Materials.	18 15			
Labour.						
Masons, 2nd class, for dressing	10	0 10 each.	6 4			
Do. for setting ...	6	0 10 do.	3 12			
Nowgunnies	6	0 5 do.	1 14			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	$\frac{1}{2}$	0 8 do.	0 4			
Smiths	$\frac{1}{2}$	0 12 do.	0 6			
Bellows-boys	$\frac{1}{2}$	0 4 do.	0 2			
Grinding chunam C. F.	24	3 0 100 C. F.	0 11			
Scaffolding	...	... ...	1 0			
Sundries	...	... ...	0 12			
		Total Labour...	16 3			
Total for 100 C. F. ...			35 2	Total for 100 C. F....		

Note.—The following table gives the approximate cost of framed teak wood centerings for segmental arches of culverts and bridges of the undermentioned spans for a clear roadway of 20 feet, including cost of erecting and lowering :—

Span in feet.	Cost per running foot of span.	Total cost.	Span in feet.	Cost per running foot of span.	Total cost.
	Rs. a. p.	Rs. a. p.		Rs. a. p.	Rs. a. p.
3	13 0 0	39 0 0	15	25 0 0	375 0 0
4	14 0 0	56 0 0	20	30 0 0	600 0 0
5	16 0 0	80 0 0	25	35 0 0	875 0 0
6	18 0 0	108 0 0	30	40 0 0	1,200 0 0
8	20 0 0	160 0 0	35	45 0 0	1,575 0 0
10	22 0 0	220 0 0	40	50 0 0	2,000 0 0

LIV.—Brick Arching for Bridges.

May be taken as brick-work under XLVIII, adding for centering as in page 91.

LV.—Brick Arching over doors and windows, 1st Class.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks 9″ × 4¼″ × 2½″, allowing 5 per cent. for wastage... ...	1550	12 0 1,000	18 10			
Lime, slaked ...C. F.	16	12 0 40 C. F.	4 13			
Sand ... ...C. F.	24	2 0 100 C. F.	0 8			
Timber for centering...	...	... ...	0 4			
Sundries	...	... ...	0 6			
		Total Materials.	24 9			
Labour.						
Bricklayers for laying .	6	0 10 each.	3 12			
Lo. for dressing bricks ...	4	0 10 do.	2 8			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Carpenter for centering	½	0 12 do.	0 6			
Grinding chunam. C. F.	24	3 0 100 C. F.	0 11			
Sundries	...	... ...	0 6			
Scaffolding	...	... ...	1 0			
		Total Labour ...	10 1			
		Total for 100 C. F....	34 10		Total for 100 C. F....	

LVI.—Brick Arching over doors and windows, 2nd Class.

Artificers, Labourers, and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks 9″ × 4¼″ × 2½″ ...	1425	8 0 1,000	11 6			
Lime, slaked ... C. F.	20	12 0 40 C. F.	6 0			
Sand... ... C. F.	30	2 0 100 C. F	0 10			
Timber for centering...	..	... ...	0 4			
Sundries	...	... ...	0 4			
		Total Materials.	18 8			
Labour.						
Brick-layers for laying.	5	0 10 each.	3 2			
Do. for dressing.	3	0 10 do.	1 14			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Grinding chunam C. F.	30	3 0 100 C. F.	0 14			
Carpenter for centering	½	0 12 each.	0 6			
Scaffolding	...	... ...	1 0			
Sundries	...	... ...	0 5			
		Total Labour...	8 15			
		Total for 100 C.F...	27 7		Total for 100 C. F....	

LVII.—Concrete of Road Metal.

Artificers, Labourers, and Materials for 100 Cubic feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Road Metal ... C. F.	100	4 0 100 C. F.	4 0			
Sand ... C. F.	46	2 0 do.	0 15			
Lime, slaked ... C. F.	23	12 0 40 C. F.	6 14			
Sundries	...	... ...	0 3			
		Total Materials .	12 0			
Labour.						
Grinding chunam C. F.	46	3 0 100 C.F.	1 6			
Coolies ... No.	8	0 3 each.	1 8			
Bhisties	½	0 8 do.	0 4			
Sundries	...	.. ...	0 4			
		Total Labour...	3 6			
Total for 100 C. F. Road metal, concrete...			15 6		Total for 100 C. F. Road metal, concrete.	

LVIII.—Concrete of broken brick and kunker.

Artificers, Labourers and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Broken bricks ...C. F.	50	5 0 100 C.F.	2 8			
Kunker chunam...C. F.	50	5 0 100 C.F.	2 8			
Sand ...C. F.	25	2 0 100 C.F.	0 8			
Lime, slaked ...C. F.	25	12 0 40 C.F.	7 8			
Sundries	...	... ...	0 3			
		Total Materials.	13 3			
Labour.						
Grinding chunam C.F.	25	3 0 100 C.F.	0 12			
Coolies...	8	0 3 each.	1 8			
Bhisties	¾	0 8 do.	0 6			
Sundries	...	... ...	0 3			
		Total Labour ...	2 13			
Total for 100 C.F. broken brick and kunker, concrete			16 0		Total for 100 C. F. broken brick and kunker, concrete...	

LIX.—Cement Concrete.

Artificers, Labourers and Materials for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a Per	Rs. a.		Rs. a Per	Rs. a.
Materials.						
Road Metal ... C. F.	96	6 0 100 C. F.	5 12			
Sand... ... C. F.	48	2 0 do.	1 0			
Portland Cement, 6 casks or ... C. F.	24	10 0 4 C. F.	60 0			
Sundries	...	... ...	1 4			
		Total Materials.	68 0			
Labour.						
Coolies ... No.	6	0 3 each.	1 2			
Bhisties	1	0 8 do.	0 8			
Sundries	...	... ...	0 6			
		Total Labour ...	2 0			
		Total for 100 C. F. ...	70 0		Total for 100 C. F.	

IV.—FLOORING SPECIFICATIONS.

	Page.
LX.—Paving, 1st Sort	99
LXI.— „ 2nd „	99
LXII.— „ 3rd „	99
LXIII.— „ 4th „	99
LXIV.—Paving (upper storey, 1st Sort)	100
LXV.— „ 2nd Sort	100
LXVI.—Brick (flat)	100
LXVII.— „ (edge)	100
LXVIII.—Chunam or Terraced Floors	100
LXIX.—Asphalt Flooring	100
LXX.—Bastard Asphalt	101
LXXI.—Minton's Tiles	102
LXXII.—Wooden (Ground Floors)	102
LXXIII.—Floor Planking	103
LXXIV.—Single Flooring	103
LXXV.— „ „	103
LXXVI.—Double Flooring	104
LXXVII.— „ „	104
LXXVIII.—Composite Flooring No. 1	104
LXXIX.— „ „ No. 2	105

IV.—FLOORING SPECIFICATIONS.

LX.—Paving, 1st Sort.

Filling. 1. The moorum filling to be levelled, watered, and well rammed before the concrete is put in.

Concrete. 2. A concrete substratum to be laid 6″ thick, when thoroughly rammed. Concrete to be as in Specification No. LVII.

Dressing. 3. The stones to be very finely flat chisel-dressed on the surface and the courses to be of uniform width, so that the joints may run true and parallel from side to side.

Joint. 4. The stones to be laid with joints not exceeding $\frac{1}{8}$″ in thickness, and to be evenly and firmly bedded flush in mortar on the concrete, and no hollows to be left.

Size. 5. The stones to be 3″ or 4″ thick, and not less in length and breadth than 12″ × 12″ laid to a perfectly smooth and level surface.

Vertical joints. 6. Vertical joints to be dressed true and square for at least 1$\frac{1}{2}$″ from face.

Note.—Suitable for architectural buildings.

LXI.—Paving, 2nd Sort.

As above but not quite so finely dressed, joints may be $\frac{3}{16}$″ thick and dressed true 1″.

Note —Suitable for barracks.

LXII.—Paving, 3rd Sort.

As above, but only rough point chisel-dressed, with $\frac{1}{4}$″ joints and true for $\frac{1}{2}$″, and size of stones to be not less than 12″ × 6″. Concrete 3″ thick when rammed.

LXIII.—Paving, 4th Sort.

Irregular-shaped and sized stones roughly dressed, with point chisel, joints $\frac{3}{8}$″, true for $\frac{1}{2}$″. Concrete 3″ thick when rammed.

Note.—The last two sorts are only suited for minor buildings, such as cookhouses, dharmshálas, &c.

LXIV.—Paving for upper story, 1st Sort.

1. To be laid over joists, to be of thin slabs of uniform thickness (if of Porebandar stone to be not less than 2½″ thick), dressed true and square on the edges to make close joints ⅛″ for the full thickness of the stone.

Slabs.

2. The surface to be as for paving, 1st sort. The stones to be of such length and breadth that the joints shall come exactly in the middle of the joists, and that the cross joints shall be in a straight line.

Size.

3. The joints to be made with Portland cement.

Cement joints.

Note.—If the slabs are to be under concrete for floors or roofs, the upper side need not be dressed, and the stones can be set in ordinary mortar, and joints can be ¼″ thick.

LXV.—Paving for upper story, 2nd Sort.

Same as above generally, but the surface of the slabs to be dressed as for paving 2nd sort, and the edges true and square to make joints $\frac{3}{16}$″ for the full thickness of the stone.

LXVI and LXVII.—Brick or tiled floor.

1. The bricks or tiles will be laid on 6″ of concrete. The joints to be rubbed, and the hardest and best burnt bricks to be selected. To be thoroughly wetted and set in lime mortar.

2. Bricks to be laid on edge or flat as may be specified for particular work.

LXVIII.—Chunam or Terraced Floors.

1. The moorum filling to be levelled, watered, and well rammed before the concrete is put in.

Filling.

2. The floor will be composed of concrete as in Specification No. LVII. 6″ thick when consolidated. The concrete to be rammed well for three consecutive days with wooden or iron beaters: three coolies at least per day to be employed per square.

Consolidation.

3. When the consolidation is considered by the Executive Engineer to be complete, finish with a coat of plaster at least ¾″ thick and beat surface with flat beaters for three days: three coolies at least per day to be employed per square. The plaster to contain such proportions of masála as may be directed.

Plaster.

LXIX.—Asphalt Flooring.

1. To be laid on a concrete floor as per paras. 1 and 2 of Specification No. LXVIII. above, which must be perfectly dry before the asphalt is laid.

Substructure.

2. All dust and sand should first be cleared off the site, and the asphalt having been mixed and melted in the following proportions (unless otherwise specified)—

Proportions.

Asphalt	...	...	... 1 part.
Bitumen	...	...	... $\frac{1}{3\frac{1}{2}}$ „
Clean sharp sand		...	... $\frac{1}{2}$ „

will then be laid on smoothly and equally $\frac{1}{2}''$ (or $\frac{3}{4}''$ as specified) thick, and will be carefully and steadily rubbed with a hand float until the surface is perfectly even and true.

3. The junctions of the sections of the asphalting are to be carefully made, and before the surface becomes hard it is to be worked off perfectly level and smooth with fine clean sand, and to be left of a uniformly dark colour.

Finishing off.

LXX.—Bastard Asphalt Flooring.

1. This description of flooring will consist of a layer of road metal boiled in coal tar, the upper surface when spread and rolled being finished off with a coat of materials consisting of coarse gravel and slaked lime boiled in a mixture of pitch and coal tar, sanded, and finally rolled.

Description.

2. The formation having been properly levelled and thoroughly rolled, upon its surface will be spread, whilst hot, a six-inch layer of materials consisting of *one inch cube* road metal well boiled in coal tar. The materials when spread to be thoroughly consolidated with an iron or stone roller, kept well wetted whilst in use.

First layer of materials.

Note.—The coal tar used should be of moderate consistency and well boiled; if too liquid, it will prevent the proper adhesion of the materials when rolled.

3. On this a half-inch coat of materials will be spread, consisting of

(1) Small stone chips or coarse gravel ... 2 parts.
(2) Slaked lime ... ... 1 part.

boiled in a mixture of pitch and coal tar in the proportion of one of the former to two of the latter. This mixture will also be applied hot, and then carefully and evenly spread out.

Second layer of materials.

Note.—Pounded hard burnt brick, or kunker slags, may be substituted for the small stone chips or coarse gravel.

4. The surface thus formed to be then covered with a $\frac{1}{4}$-inch layer of very fine sharp sand, and finally rolled.

Finishing.

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5. The work to be carried out in successive widths corresponding with the length of the roller to be used in its consolidation, so that the whole width may be evenly rolled as the roller passes over it each time. Battens, say 3″ × 6″ and about 9 feet in length, to be set on edge and secured in position along the outer or exposed edges of each width of flooring whilst the work is in progress, so as to confine the materials therein whilst the process of spreading and rolling is going on. On the completion of the first width they will be removed and again fixed in new positions to admit of a second width being laid, and so on. Care to be taken to well paint the last joint before adding a fresh width, in order to secure proper adhesion of the materials throughout.

Method of carrying out the work.

Note.—This description of flooring has been used on the G. I. P. Railway in goods' shed platforms, &c., and found to be durable, and answer well in all cases when not exposed to the action of the sun. In the floors of ordinary buildings its depth need not exceed 3 inches. Its cost per 100 superficial feet (even when 6 inches in thickness) is less than half that of the commonest description of stone paving (Specification No. LXIII.)

LXXI.—Minton's Tiles Floor.

1. Concrete bedding formed as per paras. 1 and 2 of Specification No. LXVIII to be evenly covered with a coat of mortar, and truly levelled after an interval of two or three days.

Bedding.

2. The tiles to be carefully set in Portland Cement on surface thus prepared. For every 100 square feet of tiles not less than ¾ cask of cement should be used.

Setting in Cement.

3. The floors should be thoroughly washed within ten days of completion of each portion, and handed over clean.

Cleaning.

Pattern.

4. Pattern to be approved by Executive Engineer.

LXXII.—Wooden Flooring for Ground Floors.

1. The foundation to consist of two layers of concrete, each 3 inches deep, on which will be placed at 2 feet clear intervals, both along the length and breadth of the room, blocks of stone or brick masonry 9 inches square. On these blocks will rest flooring joists 4″ × 4″, which will support the planked flooring.

Description of Foundation.

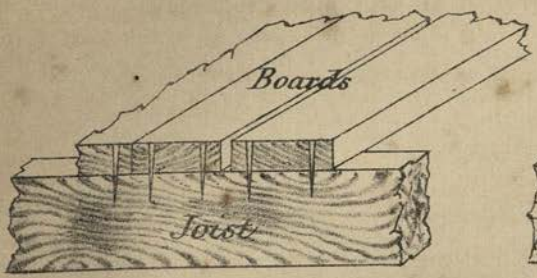
Joists.

2. The concrete to be prepared and laid in accordance with Specification No. LVII. In ramming the concrete care to be taken by constant tests to ensure the required level being maintained, and the floor having an even surface.

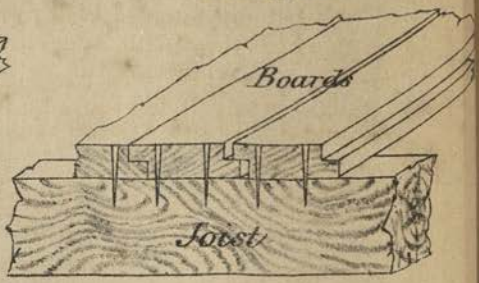
Concrete.

Different methods of laying Floor Boards.

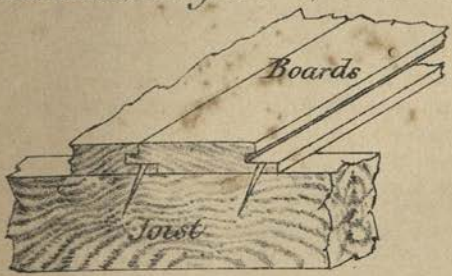
Plain Jointed



Rebated



Rebated, Tongued & Grooved



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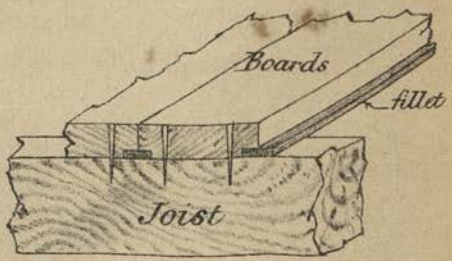
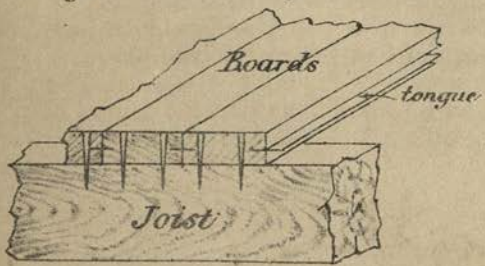
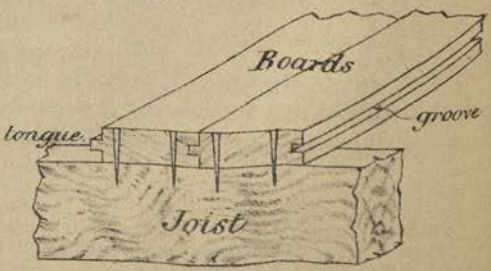


Tongued & Ploughed



Tongued & Grooved



Govt Photozinco Office, Poona, 1886

3. A sufficient number of air passages to be provided through the walls to admit of a free circulation of air under the planked floor; the outer mouths of these passages to be covered with strong iron wire netting of ¼ inch meshes.

Air passages.

4. The floor boarding to consist of teak planks 1½ inches thick and not more than 6 inches wide, tongued and grooved (or tongued and ploughed as may be specified), screwed to the joists below with screws 2½ inches long, their heads being countersunk into the planks, and the upper surface of the planks then planed smooth. The heading joints to be rebated and tongued, and to rest in all cases upon the bridging joists to which they will be secured by two screws, and to break joint with one another.

Floor boarding.

LXXIII.—Floor Planking.

Timber. 1. To be of the best Moulmein Teak boards, thoroughly seasoned, and of the greatest length procurable.

Scantlings. 2. Boards to be 1½ inches thick, and from 4 to 6 inches in width.

Side joints. 3. To be tongued and grooved, or tongued and ploughed, as may be specified in each instance.

4. Heading joints to rest upon the joists below, to break joint with one another, and to be rebated and tongued together.

Heading joints.

5. The boards to be jammed together as they are being laid by flooring cramps: each board to be secured in its proper position by two 2½-inch screws screwed to the bridging joists below.

Laying.

Planing. 6. The heads of all screws to be countersunk, and the exposed surfaces then planed quite smooth.

LXXIV. and LXXV.—Single Flooring.

1. To be constructed of the best Moulmein Teak Timber, well seasoned, free from sapwood, large or loose knots, shakes, or other imperfections.

Timber.

2. Bridging joists to be laid in all cases at central distances of 12 inches apart, and their ends to be nailed, cogged or notched on to the wall plates on which they rest. Their breadth may vary from 2 to 3 inches. The scantlings in each instance to be in accordance with those given in the accompanying tables. (See Table Nos. I and II.)

Bridging joists.

3. When the bridging joists exceed 10 feet in length they are to be strutted apart at intervals of about 6 feet by simple pieces of board one inch thick, fitted in between the joists at right angles to them and of their full depth.

Strutting apart.

4. Wall plates to be laid flush with the inner face of the wall and to be in as long lengths as possible; when two or more pieces are required to extend along the length of the wall their ends to be carefully scarfed together. Their scantlings to be $4\frac{1}{2}'' \times 3''$.

Wall plates.

5. Floor planking to be in accordance with Specification No. LXXIII above.

Floor planking.

6. Care to be taken that a free circulation of air is allowed round the ends of the bridging joists and along the inner side of the wall plates to which they are secured.

Ventilation.

LXXVI and LXXVII.—Double Flooring.

1. Similar in all respects as regards timber, floor planking, bridging joists, &c., to Specification No. LXXIV above.

General.

2. The bridging joists to be supported intermediately on girders placed at such central distances as may be specified from 6 to 10 feet, and to be of the scantling requisite in each case (see Table Nos. III and IV.)

Girders.

3. The ends of the girders to rest in the walls on stone or wooden templates not less than 2 to 4 feet in length, or on stone corbels built into the wall provided for that purpose.

Templates or corbels.

4. When laid on templates in the wall care to be taken to secure a free circulation of air round them.

Ventilation.

5. All floors of the above description to be laid with a rise in the centre of $\frac{3}{4}$ inch in every 20 feet to allow for the subsequent settlement which is likely to take place.

Rise in centre.

LXXVIII.—Composite Flooring No. 1.

1. The flooring to consist of 4 inches of ordinary concrete resting on a layer of paving bricks, $1\frac{3}{4}''$ to $2''$ in thickness, supported on tee iron joists and rolled iron beams as described below.

Construction.

2. The rolled iron beams to be capable of sustaining a distributed load of 200 lbs. per foot run, and to be fixed at central distances of 4 feet apart.

Rolled iron beams.

The ends of these beams to be built into the walls and to rest on bed plates of ¼ inch boiler plate iron, 18 inches long and 9 inches broad.

3. The tee iron joists to measure 2″ × 2″ × ¼″ in all cases, and to be laid (flange downwards) on the rolled iron beams above alluded to at central distances of 12½ inches apart. The continuous lengths of these joists to be secured together by means of U-shaped clips, 1½″ × ¼,″ of boiler plate iron hammered over the ends to keep them in position while the work is in progress.

Tee iron joists.

4. The spaces between the tee iron joists to be filled in with a layer of sound, well burnt paving bricks, one foot square and 1¾ to 2 inches thick, set in Portland Cement Mortar with their smooth faces downwards. The face joints of brick work to be pointed with cement from below, and this ceiling to be then finished off with one or two coats of any colour of paint that may be ordered.

Paving bricks.

5. Concrete to consist of 1 part slaked lime, 2 parts sand, and 5 parts screened shingle and to be prepared in accordance with Specification No. LVII. The upper surface of the floor to be finished off with a thin coat of cement plaster.

Concrete.

6. All iron work to be properly cleaned and then painted with one coat of red lead, to be included in the rate.

Painting.

7. The rolled iron beams to be cambered to a rise of about one inch to fifteen feet to be included in the price, and to be shored up from below while the concrete is being laid and rammed.

Camber.

Note.—This description of flooring has been used with much success in the Sind Club, and is considerably cheaper than other kinds of composite iron flooring.

LXXIX.—Composite Flooring No. 2.

1. The flooring to consist of an average thickness of 4 inches of ordinary concrete resting on wrought iron flooring plates, supported by rolled iron beams as described below.

Construction.

2. The rolled iron beams to be capable of sustaining a distributed load of 200 lbs. per foot run, and to be fixed at central distances of 5¼ feet apart. The ends of these beams to be built into the wall, resting on bed plates of 1½ inch boiler plate iron 18 inches long and 9 inches broad.

Rolled Iron Beams.

3. The flooring plates to be of Westwood and Baillie's patent trough pattern, $\frac{3}{16}$ inch thick, and weighing 10 lbs. per square foot of net area covered: to be in lengths of not less than 11 feet, and to be secured to the rolled iron beams by ¼ inch revets or bolts.

Flooring plates.

4. The flooring plates to be covered with an average thickness of 4 inches of gravel and lime concrete, and to be finished off with a coat of Portland Cement plaster $\frac{1}{2}''$ thick.

Concrete.

5. All iron work to be properly cleaned and then painted with one coat of red lead, to be included in the rate.

Painting.

6. The rolled iron beams to be cambered to a rise of about one inch to 15 feet to be included in the price.

Camber.

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATIONS.

LX.—Paving, 1st Sort.

On 6″ Concrete.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stones, rough, $12\frac{1}{2}'' \times 12\frac{1}{2}''$ each ... Supl. ft.	106	0 2 foot.	13 4			
Lime, slaked C. F.	6	12 0 40 C. F.	1 12			
Sand ... ...C. F.	6	2 0 100 C. F.	0 2			
Charcoal... ... lbs.	80	1 0 80 lbs.	1 0			
Iron ... ... lbs.	6	1 0 8 lbs.	0 12			
Sundries	...	.....	0 8			
Labour.		Total Materials.	17 6			
Masons for dressing ...	25	0 12 each.	18 12			
Do. for setting ...	12	0 12 do.	9 0			
Coolies	6	0 3 do.	1 2			
Women	6	0 2 do.	0 12			
Smiths...	$1\frac{1}{2}$	0 12 do.	1 2			
Bellows-boys	$1\frac{1}{2}$	0 4 do.	0 6			
Bhisties	$\frac{1}{4}$	0 8 do.	0 2			
Grinding chunam C. F.	6	4 0 100 C. F.	0 4			
Sundries	...	.....	0 12			
Add.		Total Labour ...	32 4			
Concrete... ...C. F.	50	15 6 100 C. F.	7 11			
Total for 100 Supl. Feet ...			57 5	Total for 100 Supl.Ft.		

LXI.—Paving, 2nd Sort.

On 6″ Concrete.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stones, rough, $12\frac{1}{2}'' \times 12\frac{1}{2}''$ each Supl. Ft.	106	0 2 Foot.	13 4			
Lime, slaked ...C. F.	9	12 0 40 C. F.	2 11			
Sand ... ...C. F.	13	2 0 100 C. F.	0 4			
Charcoal... ... lbs.	60	1 0 80 lbs.	0 12			
Iron ... ... lbs.	4	1 0 8 lbs.	0 8			
Sundries	...	...	0 10			
		Total Materials.	18 1			
Labour.						
Masons, for dressing ...	12	0 12 each.	9 0			
Do. for setting ...	10	0 12 do.	7 8			
Coolies...	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Smiths...	1	0 12 do.	0 12			
Bellows-boys	1	0 4 do.	0 4			
Bhisties	$\frac{1}{4}$	0 8 do.	0 2			
Grinding chunam C. F.	13	3 0 100 C. F.	0 6			
Sundries	...	...	0 10			
		Total Labour...	20 3			
Add.						
Concrete ... C. F.	50	15 6 100 C. F.	7 11			
Total for 100 Supl. Feet ...			45 15	Total for 100 Supl. Ft.		

LXII.—Paving, 3rd Sort.

On 3" Concrete.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, Supl. ft., rough, $12\frac{1}{2}'' \times 12\frac{1}{2}''$ each ...	100	0 $1\frac{1}{2}$ foot.	9 6			
Lime, slaked ...C. F.	12	12 0 40 C. F.	3 10			
Sand ... ...C. F.	18	2 0 100 C. F.	0 6			
Charcoal... ... lbs.	30	1 0 80 lbs.	0 6			
Iron ... ... lbs.	2	1 0 8 lbs.	0 4			
Sundries... ...	...	...	0 10			
		Total Materials.	14 10			
Labour.						
Masons	8	0 12 each.	6 0			
Do.	8	0 12 do.	6 0			
Coolies	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Smiths	$\frac{1}{2}$	0 12 do.	0 6			
Bellows-boys	$\frac{1}{2}$	0 4 do.	0 2			
Bhisties	$\frac{1}{4}$	0 8 do.	0 2			
Grinding chunam C. F.	18	3 0 100 C. F.	0 9			
Sundries	...	...	0 10			
		Total Labour...	15 6			
Add.						
Concrete ... C. F.	25	15 6 100 C. F.	3 13			
Total for 100 Supl. Feet ...			33 13	Total for 100 Supl. Ft.		

LXIII.—Paving, 4th Sort.

On 3″ Concrete.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, rough, Supl. ft.	100	0 1 foot.	6 4			
Rest same as for paving, 3rd class ...	...	...	5 4			
		Total Materials.	11 8			
Labour.						
Same as for paving, 3rd sort	...	...	15 6			
Add.						
Concrete ... C. F.	25	15 6 100	3 13			
Total for 100 Supl. Feet ...			30 11	Total for 100 Supl. Ft.		

In the 3rd and 4th classes, the stones would not run more than 3″ to 4″ thick.

Note.—In buildings to be paved, the top of the plinth should be kept at least 6″ below floor-level; otherwise tops of stones of plinths have frequently to be knocked out, thereby damaging the masonry.

LXIV.—Paving for upper storey, 1st Sort.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stone, rough $1\frac{1}{2}' \times 1' \times 4''$ Supl. Ft.	106	0 3 foot.	19 14			
Portland Cement, one barrel or C. F.	4	10 0 4 C.F.	10 0			
Charcoal ... lbs.	120	1 0 80 lbs.	1 8			
Iron ... ... lbs.	8	1 0 8 lbs.	1 0			
Sundries		.....	0 12			
		Total Materials.	33 2			
Labour.						
Masons for dressing ...	44	0 12 each.	33 0			
Do. for setting ...	8	0 12 do.	6 0			
Nowgunnies	4	0 5 do.	1 4			
Coolies	4	0 3 do.	0 12			
Women	4	0 2 do.	0 8			
Smiths	2	0 12 do.	1 8			
Bellows-boys	2	0 4 do.	0 8			
Bhisties	$\frac{1}{4}$	0 8 do.	0 2			
Sundries		.....	0 12			
		Total Labour...	44 6			
		Total for 100 Supl. Feet...	77 8		Total for 100 Supl. Ft.	

N.B.—Labour and materials for bedding are not included here.

LXV.—Paving for upper storey, 2nd Sort.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, Supl. ft., rough 18″ × 12″ × 4″ ...	106	0 3 foot.	19 14			
1½ barrel Portland Cement, or ... C. F.	6	10 0 4 C. F.	15 0			
Charcoal ... lbs.	90	1 0 80 lbs.	1 2			
Iron ... ... lbs.	6	1 0 8 lbs.	0 12			
Sundries	...	.....	0 10			
		Total Materials.	37 6			
Labour.						
Masons for dressing ...	33	0 12 each.	24 12			
Do. for setting ..	6	0 12 do.	4 8			
Nowgunnies	4	0 5 do.	1 4			
Coolies	4	0 3 do.	0 12			
Women	4	0 2 do.	0 8			
Smiths...	1½	0 12 do.	1 2			
Bellows-boys	1½	0 4 do.	0 6			
Bhisties	½	0 8 do.	0 4			
Sundries	...	.....	0 10			
		Total Labour...	34 2			
		Total for 100 Supl. Feet...	71 8		Total for 100 Supl. Ft.	

N.B.—Labour and materials for bedding are not included.

LXVI.—Brick Floor laid flat.

On 6″ Concrete.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks 9″ × 4¼″ × 2½″ allowing 5 per cent. for wastage... ...	375	12 0 1,000	4 8			
Lime, slaked C.F.	4	12 0 40 C.F.	1 3			
Sand ... ... C.F.	6	2 0 100 C.F.	0 2			
Sundries	...	.....	0 4			
		Total Materials.	6 1			
Labour.						
Bricklayers	5	0 10 each.	3 2			
Coolies for rubbing bricks	3	0 3 do.	0 9			
Women	3	0 2 do.	0 6			
Bhisties	¼	0 8 do.	0 2			
Grinding chunam C.F.	6	3 0 100 C.F.	0 3			
Sundries	...	.....	0 5			
		Total Labour...	4 11			
Add.						
Concrete .. C.F.	50	15 6 100	7 11			
		Total for 100 Supl. Feet...	18 7		Total for 100 Supl. Ft.	

LXVII.—Brick Floor laid on edge.

On 6″ Concrete.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Bricks 9″ × 4¼″ × 2½″ allowing 5 per cent. for wastage... ...	650	12 0 1,000	7 13			
Lime, slaked ... C.F.	6	12 0 40 C. F.	1 13			
Sand ... ... C.F.	9	2 0 100 C.F.	0 3			
Sundries	...	.....	0 4			
		Total Materials.	10 1			
Labour.						
Bricklayers	9	0 10 each.	5 10			
Coolies for rubbing bricks	5	0 3 do.	0 15			
Women	5	0 2 do.	0 10			
Bhisties	¼	0 8 do.	0 2			
Grinding chunam C.F.	9	3 0 100 C. F.	0 4			
Sundries	...	.....	0 6			
		Total Labour...	7 15			
Add.						
Concrete ... C.F.	50	15 6 100 C. F.	7 11			
		Total for 100 Supl. Feet...	25 11		Total for 100 Supl. Ft.	

LXVIII.—Chunam or Terraced Floor.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Concrete 6″ thick C. F.	50	15 6 100 C.F.	7 11			
Plaster ¾″ thick, rough S. F.	100	4 10 100 S.F.	4 10			
Do. fine coat S. F.	100	2 13 do.	2 13			
		Total Materials.	15 2			
Extra Labour.						
Coolies for ramming concrete	5	0 3 each.	0 15			
Women for tapping plaster	6	0 2 do.	0 12			
Sundries, such as mussála, &c.	...	.....	0 12			
		Total Labour...	2 7			
Total for 100 Supl. Feet...			17 9	Total for 100 Supl. Ft.		

LXIX.—Asphalt Flooring, ½″ thick.

On 6″ Concrete.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Concrete 6″ thick, including extra labour of ramming ...C. F.	50	16 9 100 C.F.	8 4			
Asphalt ... ...Cwt.	4	110 0 ton.	22 0			
Bitumen ... ... lbs.	14	17 0 Cwt.	2 2			
Sand, lbs. 224 or C. F.	2½	3 0 100 C.F.	0 1			
Firewood... ... lbs.	320	1 0 320 lbs.	1 0			
Sundries	...	.....	0 8			
		Total Materials.	33 15			
Labour.						
Men for spreading. No.	4	0 10 each.	2 8			
Coolies...	4	0 3 do.	0 12			
Women	2	0 2 do.	0 4			
Conveyance of Asphalt, &c., up country, say..	...	.....	5 0			
Sundries	...	.....	0 8			
		Total Labour...	9 0			
Total for 100 Supl. Feet ½″ thick Asphalt on 6″ of concrete bedding			42 15		Total for 100 Supl. Feet ½″ thick Asphalt on 6″ of concrete bedding ...	

N.B.—8 lbs. of Asphalt composition will cover 1 square foot ¾″ thick.—Molesworth.

LXX.—Bastard Asphalt Flooring, 6″ thick.

Materials and Labour for 350 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Coal Tar ... Casks.	2	11 0 cask.	22 0			
Pitch ... ... do.	½	12 8 do.	6 4			
Road Metal 1″... C.F.	175	6 0 100	10 8			
Lime ... ... C.F.	4	12 0 40	1 3			
Firewood ... lbs.	560	1 0 320	1 12			
Sundries	...	.....	1 0			
		Total Materials.	42 11			
Labour.						
Men for spreading, No	2	0 12 each.	1 8			
Coolies ... ... No.	24	0 3 do.	4 8			
Women ... ... No.	12	0 2 do.	1 8			
		Total Labour ..	7 8			
		Total for 350 Supl. Feet ...	50 3			
		Or per 100 Supl. Feet...	14 5		Or per 100 S.F. ...	

LXXI.—Minton's Tile Floor.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Minton tiles allowing 8 Supl. ft. for breakage ...Sq. Yds.	12	(In England.) 3 0 Sq.Yd.	36 0			
Portland Cement ¼ cask or ... C. F.	3	10 0 4 C.F.	7 8			
Lime, slaked ... C. F.	4	12 0 40 C.F.	1 3			
Sand ... ... C. F.	4	2 0 100 C.F.	0 1			
Sundries	...	.....	1 4			
		Total Materials.	46 0			
Labour.						
Freight and landing, &c., say 50 per cent. of the cost	...	.....	18 0			
Conveyance up country	...	.....	5 0			
Bricklayers	14	0 12 each.	10 8			
Women	14	0 2 do.	1 12			
Sundries	...	.....	1 4			
		Total Labour...	36 8			
Add.						
Concrete 6″ ...C. F.	50	16 9 100 C.F.	8 4			
Total for 100 Supl. ft. of Minton's Tile floor on 6″ of concrete			90 12		Total for 100 Supl. ft. of Minton's Tile floor on 6″ of concrete ...	

N.B.—The cost of ordinary Minton's Tiles in England varies from Rs. 3 to Rs. 6 per square yard.

LXXII.—Wooden Flooring for Ground Floors.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teak Planking $1\frac{1}{2}''$, $5\frac{1}{2}''$ clear of tongue. R.F.	220	17 0 100	37 6			
Joists $4'' \times 4''$ ...C.F.	6	3 0 C. F.	18 0			
Screws $2\frac{1}{2}''$ ... doz.	8	1 8 Gross.	1 0			
Sundries	...	... ...	0 10			
		Total Materials.	57 0			
Labour.						
Carpenters	5	0 12 each.	3 12			
Coolies	5	0 3 do.	0 15			
Carriage	...	... ...	3 12			
Sundries	...	... ...	0 9			
		Total Labour.	9 0			
Add.						
Concrete 6″ including blocks for joists. C.F.	50	17 6 100	8 11			
		Total for 100 Supl. Feet...	74 11		Total for 100 S.F....	

LXIII.—Floor Planking.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teak planking $1\frac{1}{2}''$, $5\frac{1}{2}''$ clear of tongue. R. F.	220	17 0 100 R.F.	37 6			
Screws, $2\frac{1}{2}''$ Doz.	8	1 8 Gross.	1 0			
Sundries	...	... ...	0 8			
		Total Materials.	38 14			
Labour.						
Carpenters	3	0 12 each.	2 4			
Coolies...	3	0 3 do.	0 9			
Sundries	...	... ...	0 5			
Carriage	...	... ...	3 0			
		Total Labour...	6 2			
		Total for 100 Supl. Feet...	45 0		Total for 100 Supl. Ft.	

Girders and Joists.

(1) May be taken as wrought timber, and annas six (6) per C. F. is a fair rate for labour including fixing in place, &c.

(2) For rate for floors, including girders and joists, see Nos. LXXIV and LXXVI.

LXXIV.—Single Flooring.

Weight supported 140 *lbs. per sq. foot.*

SPAN IN FEET.	Area supported.	Joists 12″ apart.					Wall Plates.					Total C. F. Joists and Wall Plates.	Rate.	Total Cost of Joists and Wall Plates.	Floor Plank at Rs. 45 per 100.	Total Cost of Area in Col. II.	Rate per 100 sq. ft.
		No.	L′	B″	D″	C. F.	No.	L′	B″	D′	C.F.						
														Rs. a.	Rs.	Rs. a.	Rs. a.
VI ..	60	10	7	2½	4	4·86						6·73		25 4	27	52 4	87 1
VIII ..	80	10	9	2½	5½	8·59						10·46		39 4	36	75 4	94 1
X ..	100	10	11	2½	6¾	12·89						14·76		55 6	45	100 6	100 6
XII ..	120	10	13	2½	8	18·05	2	10	4½	3	1·87	19·92	Rs. 3 annas 12 per C.Ft., which includes fixing in place, cost of carriage, &c., &c.	74 11	54	128 11	107 4
XIV ..	140	10	15	2½	9½	24·74						26·61		99 12	63	162 12	116 4
XVI ..	160	10	17	2½	11	32·46						34·33		128 12	72	200 12	125 8
XVIII ..	180	10	19	2½	12½	40·40						42·27		158 8	81	239 8	133 1
XX ..	200	10	21	2½	13½	49·21						51·08		191 9	90	281 9	140 12

Note.—For scantlings of Joists varying from 2 to 3 inches in breadth see Table I.

LXXV.—Single Flooring.

Weight supported 168 *lbs. per sq. foot.*

SPAN IN FEET.	Area supported.	Joists 12″ apart.					Wall Plates.					Total C. F. Joists and Wall Plates.	Rate.	Total Cost of Joists and Wall Plates.	Floor Plank at Rs. 45 per 100.	Total Cost of Area in Col. II.	Rate per 100 sq. ft.
		No.	L′	B″	D″	C. F.	No.	L′	B″	D′	C.F.						
														Rs. a.	Rs.	Rs. a.	Rs. a.
VI ..	60	10	7	2½	4½	5·16						7·03		26 6	27	53 6	88 15
VIII ..	80	10	9	2½	5½	8·98						10·85		40 11	36	76 11	95 14
X ..	100	10	11	2½	7½	13·88						15·70		58 14	45	103 14	103 14
XII ..	120	10	13	2½	8½	19·18	2	10	4½	3	1·87	21·05	Rs. 3 annas 12 per C. Ft., which includes fixing in place, cost of carriage, &c., &c.	78 15	54	132 15	110 13
XIV ..	140	10	15	2½	10	26·04						27·91		104 11	63	167 11	119 12
XVI ..	160	10	17	2½	11½	33·94						35·81		134 4	72	206 4	128 15
XVIII .	180	10	19	2½	13	42·88						44·75		167 13	81	248 13	138 4
XX ..	200	10	21	2½	14½	52·86						54·73		205 4	90	295 4	147 10

Note.—For scantlings of Joists varying from 2 to 3 inches in breadth see Table II.

LXXVI.—Double Flooring.

Weight supported 140 *lbs. per sq. foot.*

SPAN IN FEET.	Distance apart of Girders.	Area supported.	Girders 6′, 8′, and 10′ apart.					Joists 12″ apart.					Total C. F. Girders and Joists.	Rate.	Total Cost of Girders and Joists.	Floor Plank at Rs. 45.	Total Cost of Area in Col. III.	Rate per 100 S. F.
			No.	L′	B″	D″	C. F.	No.	L′	B″	D″	C. F.			Rs. a.	Rs. a.	Rs. a.	Rs. a.
XII	6	72	1	13½	6½	11½	6·85	13	6	2½	4	5·41	12·26	Rupees 3 annas 12 per C. F. which includes fixing in place, cost of carriage, &c., &c.	46 0	32 6	78 6	108 14
	8	96			7	12	7·87		8	2½	5½	9·92	17·79		66 11	43 3	109 4	114 7
	10	120			7½	12¾	8·66		10	2½	6¾	15·23	23·89		89 9	54 0	143 9	119 10
XIV	6	84	1	15½	7½	12½	9·75	15	6	2½	4	6·25	16·00		60 0	37 13	97 13	116 7
	8	112			7¾	13½	11·26		8	2½	5½	11·45	22·71		85 3	50 6	135 9	121 1
	10	140			8¼	14¼	12 65		10	2½	6¾	17·57	30·22		113 5	63 0	176 5	125 15
XVI	6	96	1	17½	8	14	13·61	17	6	2½	4	7·08	20·69		77 9	43 3	120 12	125 12
	8	128			8½	15	15·49		8	2½	5½	12·98	28·47		106 12	57 10	164 6	128 7
	10	160			9	15¾	17·22		10	2½	6¾	19·92	37·14		139 4	72 0	211 4	132 0
XVIII	6	108	1	20	8½	15½	18·53	19	6	2½	4	7·08	26·44		99 2	48 10	147 12	136 13
	8	144			9½	16½	21·44		8	2½	5½	14·51	35·95		134 13	64 13	199 10	138 10
	10	180			10	17½	23·95		10	2½	6¾	22·26	46·21		173 4	81 0	254 4	141 4
XX	6	120	1	22	9½	16½	23·94	21	6	2½	4	8·75	32·69		122 9	54 0	176 9	147 2
	8	160			10½	17¾	27·79		8	2½	5½	16·04	43·83		164 6	72 0	236 6	147 12
	10	200			10¾	18¾	30·79		10	2½	6¾	24·61	55·40		207 12	90 0	297 12	148 14
XXII	6	132	1	24	10¼	17¾	30·32	23	6	2½	4	9·58	39·90		149 10	59 6	209 0	158 5
	8	176			11	19	34·83		8	2½	5½	17·56	52·39		196 7	79 3	275 10	156 10
	10	220			11½	20	38·33		10	2½	6¾	26·95	65·28		244 13	99 0	343 13	156 4

Note.—For scantlings of Girders placed at central distances apart other than the above see Table III.

LXXVII.—Double Flooring.

Weight supported 168 *lbs. per sq. foot.*

SPAN IN FEET.	Distance apart of Girders	Area supported.	Girders 6′, 8′, and 10′ apart.					Joists 12″ apart.					Total C. F. Girders and Joists.	RATE.	Total Cost of Girders and Joists.	Floor Plank at Rs. 45.	Total Cost of Area in Col. III.	Rate per 100 S. F.
			No.	L′	B″	D″	C. F.	No.	L′	B″	D″	C. F.			Rs. a.	Rs. a.	Rs. a.	Rs. a.
XII	6	72	1	13½	6⅔	11⅔	7·43	13	6	2½	4⅓	5·75	12·18	Rupees 3 annas 12 per C. F., which includes fixing in place, cost of carriage, &c. &c.	49 7	32 6	81 13	113 10
	8	96			7⅓	12⅓	8·49		8	2⅔	5⅓	10·37	18·86		70 12	43 3	113 15	118 11
	10	120			7⅔	13¼	9·62		10	2⅔	7¼	16·36	25·98		97 7	54 0	151 7	126 3
XIV	6	84	1	15½	7½	13¼	10·69	15	6	2½	4⅓	6·64	17·33		65 0	37 13	102 13	122 6
	8	112			8¼	14¼	12·65		8	2⅔	5⅓	11·97	24·62		92 5	50 6	142 11	127 6
	10	140			8⅔	15	13·72		10	2⅔	7¼	18·88	32·60		122 4	63 0	185 4	132 5
XVI	6	96	1	17½	8½	14⅔	14·97	17	6	2½	4⅓	7·52	22·49		84 5	43 3	127 8	132 13
	8	128			9	15½	16·95		8	2⅔	5⅓	13·57	30·52		114 7	57 10	172 1	134 7
	10	160			9½	16½	19·05		10	2⅔	7¼	21·39	40·44		151 10	72 0	223 10	139 12
XVIII	6	108	1	20	9½	16	20·55	19	6	2½	4⅓	8·41	28·96		108 10	48 10	157 4	145 10
	8	144			9⅔	17	23·02		8	2⅔	5⅓	15·17	38·19		143 3	64 13	208 0	144 7
	10	180			10½	18	26·25		10	2⅔	7¼	23·91	50·16		188 2	81 0	269 2	149 8
XX	6	120	1	22	10	17⅔	26·35	21	6	2⅔	4⅓	9·29	35·64		133 10	54 0	187 10	156 6
	8	160			10⅔	18⅔	30·38		8	2⅔	5⅓	16·77	47·15		176 13	72 0	248 13	155 8
	10	200			11¼	19⅔	33·51		10	2⅔	7¼	26·43	59·94		224 12	90 0	314 12	157 6
XXII	6	132	1	24	10⅔	18⅔	33 14	23	6	2⅔	4⅓	10·18	43·32		162 7	59 6	221 13	168 1
	8	176			11⅓	19¾	37·85		8	2⅔	5⅓	18·36	56·21		210 12	79 3	289 15	164 12
	10	220			12	21	42·00		10	2⅔	7¼	28·94	70·94		266 0	99 0	365 0	165 15

Note.—For scantlings of Girders placed at central distances apart other than the above, see Table IV

LXXVIII.—Composite Flooring No. 1.

Span in Feet.	Area supported.	Rolled Iron Beams 4 feet apart at Rs. 10 per Cwt. including Cost of Carriage, Painting and Fixing.							Cost of T Irons, concrete and paving bricks laid complete, at 44 Rs. 14 annas per 100 S. F.	Contingencies, including bed plates &c., at 5 per cent.	Total Cost of area in Col. II.	Rate per 100 S. F. of Flooring complete.
		Length in feet.	Height of web.	Breadth of flange.	Thickness of web.	Weight in lbs. per R. Ft.	Total weight in lbs.	Cost.				
		′	″	″	″			Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.
VI	24	8	$4\frac{3}{4}$	2	$\frac{1}{4}$	8	64	5 11	10 12	0 13	17 4	71 14
VIII	32	10	$4\frac{3}{4}$	$2\frac{7}{8}$	$\frac{5}{16}$	11	110	9 13	14 6	1 3	25 6	79 5
X	40	12	$5\frac{1}{2}$	3	$\frac{1}{2}$	15	180	16 1	17 15	1 11	35 11	89 3
XII	48	14	$7\frac{1}{8}$	$3\frac{5}{8}$	$\frac{5}{16}$	18	252	22 8	21 9	2 3	46 4	96 6
XIV	56	$16\frac{1}{2}$	$9\frac{1}{4}$	$3\frac{9}{16}$	$\frac{3}{8}$	22	363	32 7	25 2	2 14	60 7	107 15
XVI	64	$18\frac{1}{2}$	$9\frac{5}{16}$	$3\frac{7}{8}$	$\frac{19}{32}$	29	536·5	47 14	28 12	3 13	80 7	125 11
XVIII...	72	$20\frac{1}{2}$	10	5	$\frac{1}{2}$	36	738	65 14	32 5	4 15	103 2	143 4
XX	80	$22\frac{1}{2}$	10	$5\frac{1}{4}$	$\frac{23}{32}$	44	990	88 6	35 14	6 3	130 7	163 1
XXII	88	$24\frac{1}{2}$	10	6	$\frac{7}{16}$	50	1,225	109 6	39 8	7 7	156 5	177 10
XXIV...	96	$26\frac{1}{2}$	12	6	$\frac{9}{16}$	56	1,484	132 8	43 4	8 13	184 9	192 4

Note.—The dimensions shown in this table have been calculated to support a load of 200 lbs. per S. F. as below :—

Weight of flooring	60 lbs.
Live load	140 ,,
Total ...	200 ,,

LXXVIII.—Composite Flooring No. 1.

(Details of Rate in Column No. X. of foregoing table.)

Artificers, Labourers, and Materials for 100 Square feet.	Number or Quantity.	Rate.	Per	Amount.
		Rs. a.		Rs. a.
Materials.				
Bricks 12″×12″×2″, allowing 5 per cent. for wastage	105	40 0	1,000	4 3
Portland Cement ... ...C. F.	3	9 0	4 C. F.	6 12
Sand ... ...C. F.	6	2 0	100	0 2
Sundries	.....	...	...	0 4
Total Materials ...				11 5
Labour.				
Brick-layers ... ... No.	4	0 10	Each.	2 8
Coolies for rubbing bricks ... „	3	0 3	„	0 9
Women ... ... „	3	0 2	„	0 6
Bhisties ... ... „	¼	0 8	„	0 2
Sundries ... ... „	...	...	...	0 5
Total Labour ...				3 14
Total for 100 S. F. for brick floor laid in cement				15 3
Add—				
Concrete of shingle 4″ thick				5 2
Tee iron 100 + 10 = 110 × 3·13 = 344 lbs. at Rs. 8 per cwt. which includes fixing in place, painting &c., complete				24 9
Cost for 100 S. F. of floor for laying bricks, concrete and Tee iron				44 14

LXXIX.—Composite Flooring No. 2.

Materials and Labour for 126 Square feet.	Number or Quantity.	Rate.	Per	Amount.
		Rs. a.		Rs. a.
Materials.				
R. I. Beams, 27′ long, 14″ × 6″ × 6,″ weighing 60 lbs. per foot ...Cwt.	14½	8 0	Cwt.	116 0
Westwood and Baillie's Patent Flooring Plates $\frac{3}{16}$ thick weighing 10 lbs. per square foot ... ... Cwt.	11¼	10 4	Do.	115 5
Sundries	...	...	...	5 0
Total Materials ...				236 5
Labour.				
Fixing and painting 25¼ cwt. Iron-work as above ... ...Cwt.	25¼	2 0	Cwt.	50 8
Concrete ... ...C. F.	42	15 6	100	6 7
Cement Plastering, ½″ thick ...S. F.	126	6 0	100	7 8
Sundries	...	...	...	2 0
Total Labour ...				66 7
Total for 126 S. F. ...				302 12
Or per 100 S. F....Rs.				240 4

N.B.—For flooring 24 feet span beams 5¼ feet apart.

V.—DOOR AND WINDOW SPECIFICATIONS.

DOORS.

	Page
LXXX.—Frames	129
LXXXI.—Panelled, 1st Class...	129
LXXXII.—Panelled, 2nd Class...	129
LXXXIII.—Panelled and Glazed, 1st Class	130
LXXXIV.—Panelled and Glazed, 2nd Class	130
LXXXV.—Ledged	130
LXXXVI.—Framed and Braced...	131
LXXXVII.—Iron-barred	131
LXXXVIII.—Venetianed, 1st Class	131
LXXXIX.—Venetianed, 2nd Class	132

WINDOWS.

XC.—Glazed, 1st Class	132
XCI.—Glazed, 2nd Class	132
XCII.—Plank Shutters	132
XCIII. —Iron barred...	132
XCIV.—Glass and Venetian, 1st Class	133
XCV.—Glass and Venetian, 2nd Class	133
XCVI.—Glazed, Barred, and Shutters	133

V.—DOOR AND WINDOW SPECIFICATIONS.

LXXX.—Door and Window Frames.

1. To be of Moulmein teak, of the scantlings shown in the drawings, or as specified in Tables V, XI and XII. *Wood.*

2. To be properly framed and morticed together, and to be set solidly in the masonry, the parts hidden by masonry to be tarred with boiling coal tar. *Fixing.*

3. To be rebated one side ½″ wide and full thickness of shutter, and to have a return bead moulded on the other side, or chamfered as may be directed. *Moulding.*

4. To be paid for by actual cubic content; curved frames for fanlights to be included in this item. *How paid for.*

Note.—Curved frames are usually paid for at double the rate for straight work.

DOORS.

LXXXI.—Doors, Panelled, 1st Class.

1. Door to be "hung folding" to be of 6 equal panels, 3 panels in height and 2 in breadth. *Description.*

2. Frame to be as in Specification No. LXXX. above. *Frame.*

3. The styles, top, bottom, lock and frieze rails to be moulded on both sides with ovolo and fillet moulding (unless otherwise specified). *Styles and rails.*

4. The panels to be raised, feather-tongued into styles and rails, with beaded edges on both sides. The corners of the raised portion of the panels to be rounded off as shown in the drawings. *Panels.*

5. Each leaf to be hung with brass butt (or back flap) hinges fixed with brass screws and furnished with brass mortice lock with patent handles, brass flush bolts, and brass hooks with brass eyes in frame to keep the shutters open. *Furniture.*

6. Unless otherwise specified, the several parts to be of the dimensions stated in the tables to be found in another part of this book. (Table VI.) *Dimensions.*

LXXXII.—Doors, Panelled, 2nd Class,

1. To be similar in all respects, except the following, to Specification No. LXXXI above. *Description.*

Styles, rails and panels.

2. Styles and rails to be chamfered on both sides instead of moulded, and the raised panels to have square corners and edges on both sides.

LXXXIII.—Doors, Panelled and Glazed, 1st Class.

Description.

1. To be similar in all respects, except the following, to Specification No. LXXXI above. The four upper panels to be glazed instead of panelled. The styles and rails to be rebated ½″ wide on the inside to receive glass instead of being moulded.

Sash bars.

2. Sash bars to be moulded and mitred on the outside, and rebated ½″ wide on the inside to receive glass.

Glazing.

3. Glazing to be of best English crown glass 21 oz. Each pane will be cut to fit the rebates truly, and secured with iron sprigs and putty in the usual manner.

LXXXIV.—Doors, Panelled and Glazed, 2nd Class.

Description.

1. Same as above, but chamfered edges to styles, rails, &c., and raised panels to have square edges and corners.

Furniture.

2. Furniture to be of iron throughout instead of brass, with the exception of the lock, which will be as above.

LXXXV.—Doors, Ledged, or Batten.

Description.

1. To consist of framed vertical boards connected together by two or three pairs of horizontal ledges nailed across the back of the door.

Boards.

2. The boards to be planed, tongued and grooved, or rebated together as may be specified. One edge of each board to be beaded on the outside.

Hung folding.

3. Door to be "hung folding" when its width exceeds 3 feet.

Ledges.

4. Edges and ends of ledges to be chamfered.

Furniture.

5. Each leaf to be hung with iron cross garnet or strap hinges screwed to the ledges, or with strong iron butt hinges as may be specified. To be provided with iron bolts, hooks and eyes, and an alldrop bolt and padlock.

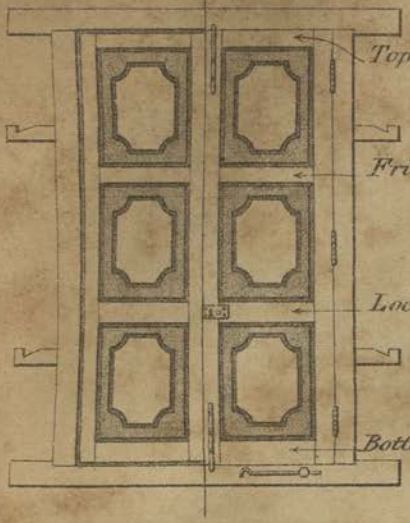
Dimensions.

6. Unless otherwise specified, the several parts to be of the dimensions shown in the tables (Table VIII.)

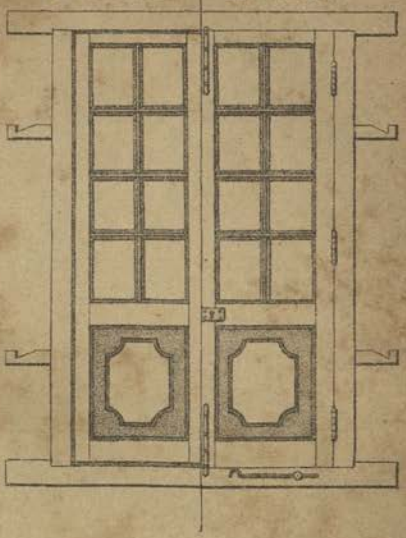
Doors.

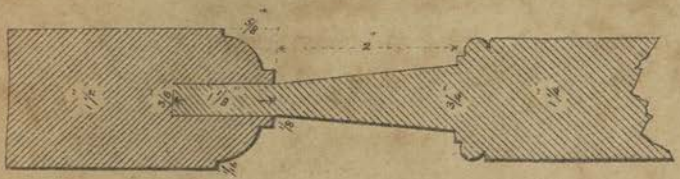
Plate IX.

Door, Panelled.

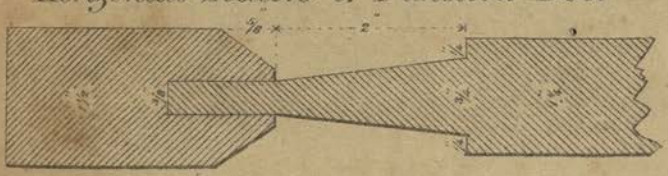


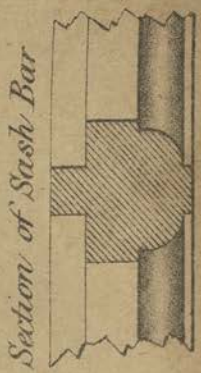
Door, Panelled & Glazed





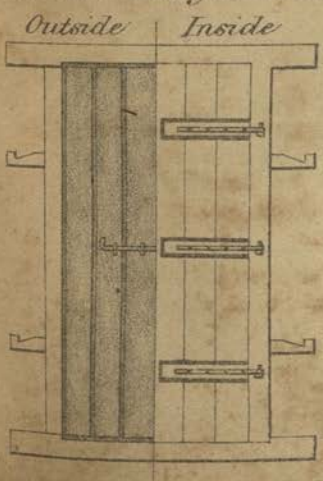
Horizontal Section of Panelled Door



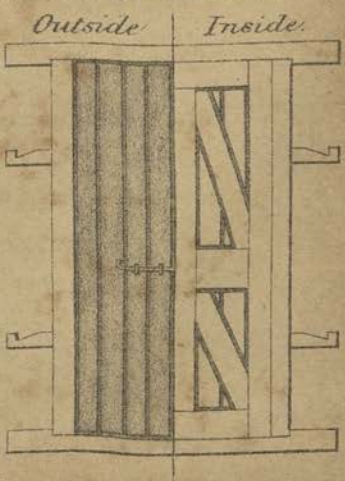


Section of Sash Bar

Planked or Ledged Door

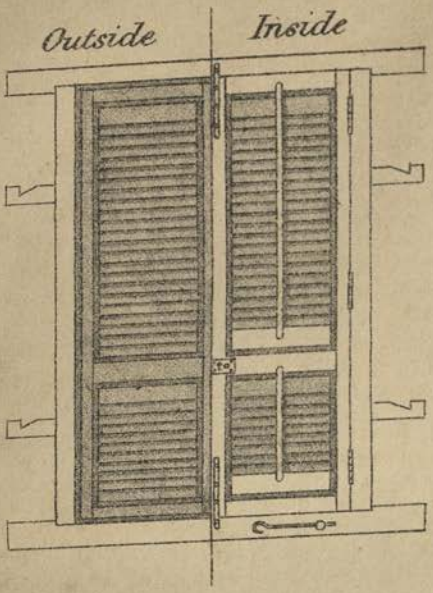


Framed & Braced Door.



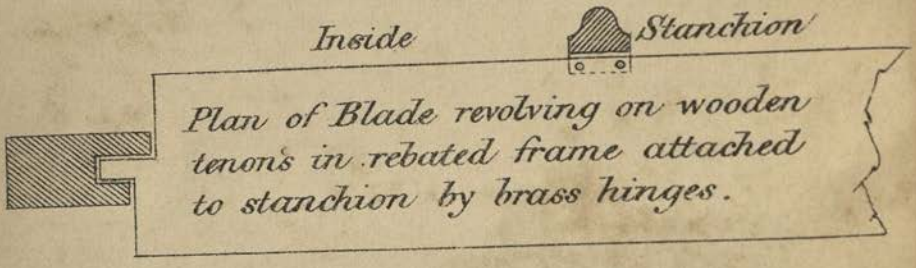
Govt Photozinco. Office, Poona. 1887

Door Venetianed

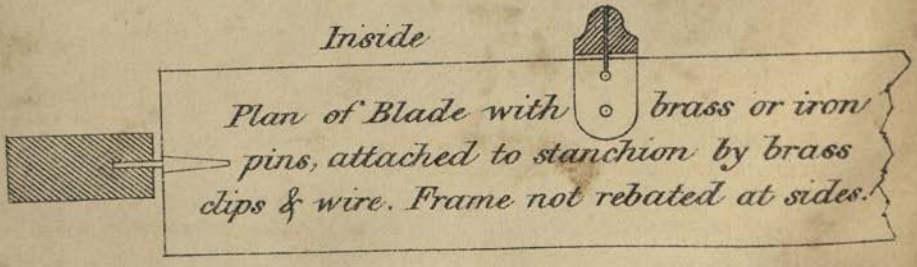


Section through Venetians showing straight rebate in side of frame.

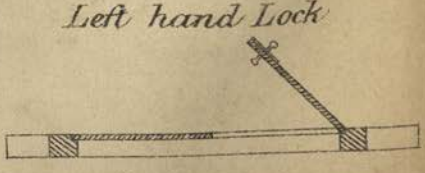
Section showing rebate in side of frame to fit Venetian.



Plan of Blade revolving on wooden tenons in rebated frame attached to stanchion by brass hinges.



Plan of Blade with brass or iron pins, attached to stanchion by brass clips & wire. Frame not rebated at sides.



Govt. Photozinco. Office, Poona, 1887

LXXXVI.—Doors Framed and Braced.

Description. 1. To consist of vertical boards secured together in a frame-work of wood.

Frame-work. 2. The frame-work to consist of styles, top, bottom and centre rail with a diagonal brace between the top and centre and centre and bottom rails respectively: edges chamfered or beaded on the inside.

Boards. 3. The boards to be planed, rebated together, and fixed flush with the outside of the frame. One edge of each board to be beaded on both sides.

Dimensions. 4. Frame-work to be $1\frac{1}{2}''$ to $2''$ thick according to size of door: battens from $\frac{5}{8}$ to $\frac{7}{8}$ inch thick.

Hung folding. 5. Door to be "hung folding" when its width exceeds 3 feet.

Furniture. 6. Each leaf to be hung with iron cross garnet or strap hinges screwed to the top, centre, and bottom rails, or with strong iron butt hinges as may be specified. To be provided with iron bolts, hooks and eyes, and an alldrop bolt and padlock.

LXXXVII.—Doors, with Iron barred, and Plank Shutters.

Description. 1. Double shutters, outer pair of shutters planked, and the inner filled in with round iron bars.

Frame. 2. Frame to measure not less than $6'' \times 4\frac{1}{2}''$, and to be rebated $\frac{1}{2}''$ wide all round on both sides and full thickness of the shutters. In all other respects to be similar to Specification No. LXXX.

Plank shutter. 3. To be in accordance with Specification No. LXXXV (see "Doors Ledged"), but to be hung with 3 pairs strong iron back flap hinges so that they may open back against the wall.

Iron barred shutters. 4. Styles, top, bottom, and lock rails to be $2\frac{1}{4}''$ thick, framed together and filled in with round iron bars $\frac{3}{4}$ to 1 inch in diameter fixed at 4 inches central distances apart. The bars to be housed into the top and bottom rails to a depth of one inch, and to be passed through the lock rail. To be hung with 3 pairs strong iron butt hinges.

Furniture. 5. Iron bolts, hooks and eyes, and an alldrop bolt and padlock to be provided for each pair of shutters.

LXXXVIII.—Doors, Venetianed, 1st Class.

Description. 1. Shall be the same in all respects as Specification No. LXXXI except that the panels (of which there will be 4 only) will be filled in with venetians.

2. The blades to be 3½″ wide and ⅝″ thick, and to overlap about half their width. To be secured to the moulded stanchion by brass hinges 1″ wide, and to have rounded edges.

Blades.

3. The frame of each shutter to be rebated all round *outside* on sides and bottom rail, and *inside* on top rail—ends of blades to be rounded off in centre to ⅜″ diameter and ¾″ long, and round holes to be made in the sides of the rebated portion of the frame to receive them.

Frame.

LXXXIX.—Doors, Venetianed, 2nd Class.

1. Same as above, except that the blades of the venetians will be attached to the moulded stanchions by clips of wire instead of brass hinges.

Description.

2. Furniture to be iron throughout as in Specification No. LXXXVIII above, with the exception of the lock, which will be as above.

Furniture.

WINDOWS.

XC.—Windows, Glazed, 1st Class.

Frame. 1. Frame to be as in Specification No. LXXX.

Shutters. 2. To open in two shutters.

Styles and rails. 3. Styles top and bottom rails to be moulded on one side, and rebated ½″ on the other to receive the glass.

Sash bars. 4. Sash bars to be moulded and mitred on one side and rebated ½″ deep on the other to receive glass.

Furniture. 5. Brass butt hinges, brass bolts, handles, and hooks and eyes to be provided.

Dimensions. 6. Unless otherwise specified, the several parts to be of the dimensions stated in the tables to be found in another part of this book. (Table XIII.)

XCI.—Windows, Glazed, 2nd Class.

Description. 1. To be similar in all respects to the above, except that styles and rails will be chamfered instead of moulded.

Furniture. 2. To be of iron instead of brass.

XCII.—Windows, Plank Shutters.

1. To be similar in all respects to Specification No. LXXXV above.

2. Furniture, Iron.

XCIII.—Windows with Iron barred and Plank Shutters.

Description. 1. Similar in all respects to the above, with the addition only that round iron bars ¾ inch in diameter will be passed through a centre rail, and fixed vertically at 3 inches central distances apart into the head and sill of the window frame.

XCIV.—Windows, Glass and Venetian Shutters, 1st Class.

Description. 1. Double shutters—outer pair of shutters venetianed and the inner glazed.

Frame. 2. Frame to be rebated ½″ wide all round on both sides and full thickness of shutters.

Venetian shutters. 3. Blades, frame, &c., to be in accordance with Specification No. LXXXVIII.

Glass shutters. 4. Glazed shutters to be similar in all respects to Specification No. XC.

XCV.—Windows, Glass and Venetian Shutters, 2nd Class.

Description. 1. To be similar in all respects to the above, except that the blades of the venetians will be attached to the moulded stanchions by clips of wire instead of by brass hinges, and the styles and rails of the glazed shutters will be chamfered instead of moulded.

2. Furniture, iron.

XCVI.—Windows Iron barred, Glazed, and Plank Shutters.

Description. 1. The glazed shutters to be fixed on the inside plank shutters, outside with iron let into the frame of the window between the two.

Glazed shutters. 2. Glazed shutters to be as in Specification No. XCI above.

Bars and plank shutters. 3. Iron bars and plank shutters to be in all respects as in Specification No. XCIII above, but without a centre rail.

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATIONS.

LXXXI.—Doors, Panelled, 1st Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	7·32	3 0 C. F.	21 15			
Butt hinges, brass, 4″ ... ...pairs	3	16 4 doz. pairs	4 1			
Mortice lock, brass ... ... No.	1	4 0 each	4 0			
Bolts, flush, brass, 10″ ... ... No.	2	13 0 dozen.	2 3			
Bolts, flush, brass, 8″ ... ... No.	1	10 0 do.	0 13			
Hooks, brass ... No.	2	0 8 each.	1 0			
Sundries	...	.....	0 8			
		Total Materials.	34 8			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 5 S. F.	8 12			
		Total Labour ...	9 12			
		Total for 28 Square Feet ...	44 4			
		Or per Square Foot...Rs.	1 9			

Note.—The dimensions in this and all the following rates relate to clear openings.

LXXXII.—Doors, Panelled, 2nd Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C.F	7·32	3 0 C. F.	21 15			
Butt hinges, iron, 4″ ... ...pairs.	3	5 12 doz. pairs.	1 7			
Mortice lock, brass ... ... No.	1	4 0 each.	4 0			
Bolts, iron, 10″ ... No.	2	8 0 dozen.	1 5			
Do. 8″ ... No.	1	6 0 do.	0 8			
Hooks, iron ... No.	2	0 2 each.	0 4			
Sundries	...	...	0 6			
		Total Materials.	29 13			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 4½ S. F.	7 14			
		Total Labour...	8 14			
		Total for 28 Square Feet...	38 11			
		Or per Square Foot...Rs.	1 6			

LXXXIII.—Doors, Panelled and Glazed, 1st Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F	6·25	3 0 C. F.	18 12			
Butt hinges, brass, 4″ ... ...pairs.	3	16 4 doz. pairs.	4 1			
Mortice lock, brass, No.	1	4 0 each.	4 0			
Bolts, flush, brass, 10″ ... ... No.	2	13 0 dozen.	2 3			
Bolts, flush, brass, 8″ ... ... No.	1	10 0 do.	0 13			
Hooks, brass ... No.	2	0 8 each.	1 0			
Panes of glass ... No.	16	0 4 do.	4 0			
Sundries	...	...	0 8			
		Total Materials.	35 5			
Labour.						
On frames ... C. F.	3·25	0 5 C. F.	1 0			
On shutters ... S. F.	28	0 5 S. F.	8 12			
		Total Labour...	9 12			
		Total for 28 Square Feet...	45 1			
		Or per Square Foot...Rs.	1 10			

See Note at the bottom of page 134.

LXXXIV.—Doors, Panelled and Glazed, 2nd Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	6·25	3 0 C.F.	18 12			
Butt hinges, iron, 4″ ... ...pairs	3	5 12 doz.pairs	1 7			
Mortice lock, brass. No.	1	4 0 each.	4 0			
Bolts, iron, 10″ ... No.	2	8 0 dozen.	1 5			
Do. do. 8″ ... No.	1	6 0 do.	0 8			
Hooks, iron ... No.	2	0 2 each.	0 4			
Panes of glass ... No.	16	0 4 do.	4 0			
Sundries	...	.....	0 6			
		Total Materials.	30 10			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 $4\frac{1}{2}$ S. F.	7 14			
		Total Labour...	8 14			
Total for	28	Square Feet...	39 8			
Or per Square Foot ... Rs.			1 7			

LXXXV.—Doors, Ledged or Batten.

$4' \times 7' \times 1\frac{1}{4}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	8	3 0 C. F.	24 0			
Butt hinges, iron, 4″ ... ...pairs	3	5 12 doz. pairs	1 7			
Bolts, iron, 10″ ... No.	1	8 0 dozen.	0 11			
Do. do. 8″ ... No.	1	6 0 do.	0 8			
Handles, iron ... No.	1	0 4 each.	0 4			
Hooks, iron ... No.	2	0 2 do.	0 4			
Alldrop bolts ... No.	1	1 0 do.	1 0			
Sundries	...	.....	0 8			
		Total Materials.	28 10			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 1½ S. F.	2 10			
		Total Labour...	3 10			
Total for	28	Square Feet ...	32 4			
Or per Square Foot ... Rs.			1 2			

See note at the bottom of page 134.

LXXXVI.—Doors, Framed and Braced.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	7·75	3 0 C. F.	23 4			
Butt hinges, iron, 4″ ... ...pairs	3	5 12 doz. pairs	1 7			
Bolts, iron, 10″ ... No.	1	8 0 dozen.	0 11			
Do. do. 8″ ... No.	1	6 0 do.	0 8			
Handles, iron ... No.	1	0 4 each.	0 4			
Hooks, iron ... No.	2	0 2 do.	0 4			
Alldrop bolts ... No.	1	1 0 do.	1 0			
Sundries ... ... No.	...	.....	0 8			
		Total Materials.	27 14			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 (			
On shutters ...S. F.	28	0 2 S. F.	3 8			
		Total Labour...	4 8			
Total for	28	Square Feet ...	32 6			
Or per Square Foot ... Rs.			1 2			

See note at the bottom of page 134.

LXXXVII.—Doors, with Iron barred and Plank Shutters.

$4' \times 7' \times 1\frac{1}{2}$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Teakwood ...C. F.	13·5	3 0 C. F.	40 8			
Butt hinges, iron, 4″ ... ...pairs	3	5 12 doz. pairs	1 7			
Back flap, do. iron, 4″ ... ...pairs	3	1 4 pair.	3 12			
Bolts, iron, 10″ ... No.	4	8 0 dozen.	2 11			
Do. do. 8″ ... No.	2	6 0 do.	1 0			
Hooks, iron ... No.	4	0 2 each.	0 8			
Alldrop bolts ... No.	2	1 0 do.	2 0			
Iron, round, 1″ ... Lbs.	105	0 1 lbs.	6 9			
Sundries	...	.....	1 0			
		Total Materials.	59 7			
Labour.						
On frames ...C. F.	4·87	0 5 C. F.	1 8			
On outer shutters .S. F.	28	0 1½ S. F.	2 10			
On inner do. S. F.	28	0 4 S. F.	7 0			
		Total Labour...	11 2			
Total for	28	Square Feet ...	70 9			
		Or per Square Foot ... Rs.	2 8			

See note at the bottom of page 134.

LXXXVIII.—Doors, Venetianed, 1st Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	6·50	3 0 C. F.	19 8			
Hinges, back flap, brass, 4″ ... ...pairs	3	4 0 pair.	12 0			
Bolts, flush, brass, 10″ No.	2	13 0 dozen.	2 3			
Do. do. 8″, No.	2	10 0 do.	1 10			
Handle, brass ... No.	1	0 8 each.	0 8			
Hooks, brass ... No.	2	0 8 do.	1 0			
Hinges, brass, for venetians ...dozen pairs	3	3 0 doz. pairs	9 0			
Mortice lock, brass. No.	1	4 0 each.	4 0			
Sundries	...	.....	0 10			
		Total Materials.	50 7			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 6 S. F.	10 8			
		Total Labour...	11 8			
Total for	28	Square Feet ...	61 15			
Or per Square Foot ... Rs.			2 3			

See note at the bottom of page 134.

LXXXIX.—Doors, Venetianed, 2nd Class.

$4' \times 7' \times 1\frac{1}{2}''$.

Materials and Labour for 28 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	6·50	3 0 C. F.	19 8			
Hinges, back flap, iron, 4" ... ...pairs	3	1 4 pair.	3 12			
Bolts, iron, 10" ... No.	2	8 0 dozen.	1 5			
Do. do. 8" ... No.	2	6 0 do.	1 0			
Handle, iron ... No.	1	0 4 each.	0 4			
Hooks, iron ... No.	2	0 2 do.	0 4			
Clips, and wire for fastening blades ...	...	.....	3 0			
Mortice lock, brass. No.	1	4 0 each.	4 0			
Sundries	...	.....	0 9			
		Total Materials.	33 10			
Labour.						
On frames ...C. F.	3·25	0 5 C. F.	1 0			
On shutters ...S. F.	28	0 6 S. F.	10 8			
		Total Labour...	11 8			
Total for	28	Square Feet ...	45 2			
Or per Square Foot ... Rs.			1 10			

XC.—Windows, Glazed, 1st Class

$4' \times 5' \times 1\frac{1}{4}''$.

Materials and Labour for 20 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ...C. F.	3·75	3 0 C. F.	11 4			
Glass, panes of, 11″ × 9″, No.	20	0 4 each.	5 0			
Butt hinges, brass, 4″, pairs.	2	16 4 doz.pairs	2 11			
Bolts, flush, brass, 8″, No.	1	10 0 dozen.	0 13			
Do. do. 6″, No.	2	6 0 do.	1 0			
Handles, brass ... No.	2	0 8 each.	1 0			
Hooks, brass ... No.	2	0 8 do.	1 0			
Sundries	...	.....	0 8			
		Total Materials.	23 4			
Labour.						
On frames ...C. F.	2·15	0 5 C. F.	0 11			
On shutters ...S. F.	20	0 4 S. F.	5 0			
		Total Labour...	5 11			
Total for	28	Square Feet ...	28 15			
Or per Square Foot ... Rs.			1 7			

See note at the bottom of page 134.

XCI.—Windows, Glazed, 2nd Class.

$4' \times 5' \times 1\frac{1}{4}''$.

Materials and Labour for 20 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	3·75	3 0 C. F.	11 4			
Glass, panes of, 11″ × 9″ No.	20	0 4 each.	5 0			
Butt hinges, iron, 4″. pairs	2	5 12 doz. pairs	0 15			
Bolts, iron, 8″ ... No.	1	6 0 dozen.	0 8			
Do. do., 6″ ... No.	2	4 0 do.	0 11			
Handles, iron ... No.	2	0 4 each.	0 8			
Hooks, iron ... No.	2	0 2 do.	0 4			
Sundries		.....	0 5			
		Total Materials.	19 7			
Labour.						
On frames ... C.F.	2·15	0 5 C.F.	0 11			
On shutters ... S.F.	20	0 3½ S.F.	4 6			
		Total Labour ...	5 1			
Total for	20	Square Feet ...	24 8			
Or per Square Foot ...Rs.			1 4			

XCII.—Windows, Plank Shutters.

3′ × 4′ × 1″.

Materials and Labour for 12 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	3	3 0 C.F.	9 0			
Butt hinges, iron, 3½″, pairs.	2	4 12 doz pairs	0 13			
Bolts, iron, 8″ ... No.	1	6 0 dozen.	0 8			
Do. do. 6″ ... No.	2	4 0 do.	0 11			
Handles, iron ... No.	2	0 4 each.	0 8			
Hooks, iron ... No.	2	0 2 do.	0 4			
Sundries	...	.....	0 5			
		Total Materials,	12 1			
Labour.						
On frames ... C.F.	1·31	0 5 C.F.	0 7			
On shutters ... S.F.	12	0 1½ S.F.	1 2			
		Total Labour ...	1 9			
Total for	12	Square Feet ...	13 10			
Or per Square Foot...Rs.			1 2			

See note at the bottom of page 134.

XCIII.—Windows, with Iron-barred and Plank Shutters.

3′×4×1″.

Materials and Labour for 12 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	3	3 0 C. F.	9 0			
Butt hinges, iron, $3\frac{1}{2}$″ pairs	2	4 12 doz. pairs	0 13			
Bolts, iron, 8″ ... No.	1	6 0 dozen	0 8			
Do. do. 6″ ... No.	2	4 0 do.	0 11			
Handles, iron ... No.	2	0 4 each	0 8			
Hooks, iron ... No.	2	0 2 do.	0 4			
Iron, round, $\frac{3}{4}$″ ... lbs.	68	0 1 lbs.	4 4			
Sundries	...	.....	0 5			
		Total Materials.	16 5			
Labour.						
On frames ... C.F.	1·31	0 5 C. F.	0 7			
On shutters ... S.F.	12	0 $1\frac{1}{2}$ S. F.	1 2			
On fixing iron bars S.F.	12	0 1 S. F.	0 12			
		Total Labour...	2 5			
Total for	12	Square Feet...	18 10			
Or per Square Foot ... Rs.			1 9			

See note at the bottom o page 134.

XCIV.—Windows, Glass and Venetian Shutters, 1st Class.

4′×5′×1½″.

Materials and Labour for 20 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	5	3 0 C.F.	15 0			
Glass, panes of, 11″×9″ No.	20	0 4 each	5 0			
Butt hinges, brass, 4″, pairs	2	16 4 doz. pairs	2 11			
Back flap do. do. 4″, pairs	2	4 0 pair	8 0			
Bolts, flush, brass, 8″No.	2	10 0 dozen	1 11			
Do. do. 6″ No.	4	6 0 do.	2 0			
Handles, brass ...No	4	0 8 each	2 0			
Hooks, brass ...No.	4	0 8 do.	2 0			
Hinges, brass, for venetians ... doz. pairs	2½	3 0 doz. pairs	7 8			
Sundries	...	.....	0 8			
		Total Materials.	46 6			
Labour.						
On frames ... C.F.	2·15	0 5 C.F.	0 11			
On outer shutters. S.F.	20	0 6 S.F.	7 8			
On inner do. S.F.	20	0 5 S.F.	6 4			
		Total Labour...	14 7			
Total for	20	Square Feet...	60 13			
		Or per Square Foot... Rs.	3 1			

See note at the bottom of page 134.

XCV.—Windows, Glass, and Venetian Shutters, 2nd Class.

$4' \times 5' \times 1\frac{1}{4}''$.

Materials and Labour for 20 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	5	3 0 C.F.	15 0			
Glass, panes of, 11″ × 9″ No.	20	0 4 each.	5 0			
Butt hinges, iron, 4″, pairs.	2	5 12 doz. pairs	0 15			
Back flap. do do. 4″, pairs.	2	1 4 pair.	2 8			
Bolts, iron, 8″ ... No.	2	6 0 dozen	1 0			
Do. do. 6″ ... No.	4	4 0 do.	1 5			
Handles, iron ... No.	4	0 4 each	1 0			
Hooks, iron ... No.	4	0 2 do.	0 8			
Clips and wire for fastening blades	...	.....	2 4			
Sundries	...	.....	0 7			
		Total Materials.	29 15			
Labour.						
On frames ... C.F.	2·15	0 5 C.F.	0 11			
On outer shutters. S.F.	20	0 6 S.F.	7 8			
On inner do. S.F.	20	0 5 S.F.	6 4			
		Total Labour.	14 7			
Total for	20	Square Feet ...	44 6			
		Or per Square Foot...Rs.	2 4			

XCVI.—Windows, Iron-barred, Glazed and Plank Shutters.

3′×4′×1″.

Materials and Labour for 12 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	3·5	3 0 C.F.	10 8			
Glass, panes of ... No.	20	0 4 each	5 0			
Butt hinges, iron, 3½″, pairs.	2	4 12 doz. pairs	0 13			
Back flap do. do. 4″, pairs.	2	1 4 pair	2 8			
Bolts, iron, 8″ ... No.	2	6 0 dozen.	1 0			
do. 6″ ... No.	4	4 0 do.	1 5			
Handles, iron ... No.	4	0 4 each	1 0			
Hooks, iron ... No.	4	0 2 do.	0 8			
Iron, round, ¾″ ... lbs.	68	0 1 lbs.	4 4			
Sundries	...	.....	0 8			
		Total Materials.	27 6			
Labour.						
On frames ... C.F.	1·31	0 5 C.F.	0 7			
On outer shutters. S.F.	12	0 1¼ S.F.	1 2			
On inner do. ... S.F.	12	0 3½ S.F.	2 10			
On fixing iron bars. S.F.	12	0 1 S.F.	0 12			
		Total Labour.	4 15			
Total for	12	Square Feet...	32 5			
Or per Square Foot...Rs.			2 11			

See note at the bottom of page 134.

VI.—CEILINGS, PLASTERING, &c.

Ceilings.

	Page.
XCVII.—Plank	153
XCVIII.—Plank (with Joists)	153
XCIX.—Cloth	153
C.—Lath and Plaster	153

Plastering.

CI.—Rough	154
CII.—Rough Cast	155
CIII.—Brick Rubbed	155
CIV.—Cement	155

Pointing.

CV.—Lime (Masonry)	155
CVI.—Lime (Brickwork)	155
CVII.—Cement	156

VI.—CEILINGS, PLASTERING, &c.

XCVII.—Plank Ceilings.

Description.

1. To be of the best Moulmein teak, or of good well seasoned pine as may be specified; and to be attached to the under side of the frame-work of the roof, so as to leave the principal roof timbers exposed to view.

Planking.

2. The boards to be ½ or ¾ inch thick and not exceeding 6 inches in width, of a uniform colour and width, tongued and grooved (or with shot edges ½″ apart and a covering fillet) planed on the under side, beaded or bevelled at the edges as may be desired.

Laying.

3. The boards to be laid truly parallel or perpendicular to the walls, and screwed to the under side of the frame-work of roof with brass screws of the proper length. The end and side joints to be neat and close. The whole to receive a coat of boiled linseed oil and then to be varnished.

Wire netting.

4. When ceilings are screwed to the under side of rafters or purlins, the boards nearest the walls and ridges to be left out, and perforated zinc or galvanized wire netting ¾″ mesh to be substituted for it.

Moulding.

5. Specify if wooden moulding to run round the top of walls is required.

XCVIII.—Plank Ceilings with Joists.

Description.

1. To be similar in all respects, except the following, to Specification No. XCVII above.

2. The boards to be screwed to teak ceiling joists 2″ × 2½″ placed at 2 feet central distance apart, screwed to the under side of tie beams of trusses.

XCIX.—Cloth Ceilings.

1. To be of strong country cloth stretched on light teakwood frames, which will rest on walls and be firmly screwed up to the tie beams. The under side of wood-work will be planed and the cloth nailed on in panels, leaving the wood-work exposed. The cloth will be white-washed, and woodwork varnished or oiled.

C.—Lath and Plaster Ceilings.

Description.

1. To consist of split male bamboos 1¼″ diameter, nailed to ceiling joists and covered above and below with lime mortar.

Laths.

2. The bamboos to be straight, and thoroughly seasoned. To be split in two, and nailed with the concave side downwards at clear distances of ⅜ inch apart to ceiling joists 2″ × 3″ at 2 feet central distance apart, and laid

to break joint. The laths to be all fixed before any plastering is commenced, and to be well wetted before plastering is applied, as also before being fixed to joists.

3. Mortar to consist of equal parts of lime and sand with the addition of clean fresh hemp; cut into lengths from 1½ to 2 inches, in the proportion of 1 lb. of hemp to 4 cubic feet of the dry ingredients of mortar. The plaster will be dashed firmly upon the laths, so as to force it between the interstices, and cause it to spread out above so as to form a shoulder resting on the lath. It will be kept wetted until fairly set and hard. The surface so formed to be thoroughly beaten, scored with a trowel and a second or finishing coat laid on ¼ inch thick and rubbed to a hard surface.

Plaster.

Whitewashing.

4. The plaster when thoroughly dry to be whitewashed.

Plastering.

CI.—Plastering Rough, ¾".

1. The joints of the work to be raked out at least ¾ inch deep so as to afford a good hold for the plaster.

Raking out joints.

2. The face of the wall to be well washed and wetted with fresh water for 6 hours before the plaster is applied.

Wetting wall.

3. A "rendering" of plaster sufficiently thick to cover by ¼" all projections of stones (¼" for rubble and ½" for brickwork should be generally sufficient) consisting of 1 part lime to 1 fine clean sharp sand, to be applied in an even and uniform coat, and to be well beaten with hand tappers.

4. Chopped hemp and jágri in the proportion of 6 lbs. of each to every 100 cubic feet of prepared mortar (or in such proportions as may be directed) to be added to the mortar.

Hemp and jágri.

If second coat is required.

5. The surface of the first coat of plaster to be well roughened while wet.

Roughen.

6. When sufficiently dry "set" with a coat of very fine lime mixed with hemp and jágri in the proportions above stated (or in such as may be directed) well rubbed in and smoothed off.

Set.

7. All mouldings will be worked true to a template and drawn neat, clean, and level. All exposed angles and junctions with door frames to be carefully finished.

Mouldings.

8. Arises to be beaded if ordered.

N.B.—Plasters to be measured on the length and height of the walls without deducting for openings which are held to be equivalent to returns and soffits.

Cornices and mouldings are to be paid for by the running foot.

Note.—The above plaster is suited for ordinary works. Several varieties of plaster for fine work are given in notes following specifications.

CII.—Plastering, rough cast ½ inch thick.

1. Is a rough plaster composed of slaked lime, mixed with coarse gravel and lime screenings, in such proportions as may be ordered, applied to the exterior of buildings about ½″ in thickness, dashed on to form a uniformly rough surface; if to be colourwashed mix the colour with the rough mortar.

CIII.—Brick rubbed rough Plaster.

1. Wet wall thoroughly, and then daub on a paste formed of pure or nearly pure lime and water at every few inches of wall, and rub freely with a soft red brick dipped in strong jágri water, say 1 lb. to the gallon. Continue the rubbing till it sets, which it does in a few minutes. The plaster should be just sufficient to hide all unequalities in the building courses.

CIV.—Cement Plastering.

1. "Render" with a mortar of equal parts of Portland cement and fine sand one inch thick and roughen, but do not beat.

2. "Set" with a ⅛-inch coat of pure Portland cement, and well smooth off.

Pointing.

CV. and CVI.—Lime Pointing.

When to be done.

1. Shall, if possible, be done while the mortar in the joints is "green" and fresh.

Raking out joints.

2. The old mortar shall be raked out of the joints at least ¾ inch deep. The dust shall then be brushed out of the joints, and the work well wetted and washed with water.

Proportions.

3. The pointing shall then be made with fine mortar of equal proportions of lime and fine sand to every cubic foot of which will be added one pound of hemp chopped fine.

Joints, raised or flat.

4. The joints of the pointed work shall be neatly defined by the pointing, and the lines shall be regular and uniform in breadth, and the joints shall be raised or flat as may be directed.

Wetting.

5. The work pointed shall be kept wet for 3 days after the pointing is complete.

Face work.

6. All face or visible work shall be pointed, unless otherwise specified.

CVII.—Cement Pointing.

1. Shall be executed as rapidly as possible, and not again touched after it has once begun to set, which it will do very soon. It must then be kept constantly wetted for some considerable time.

2. Mortar to consist of equal parts of Portland cement and sand.

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATION.

XCVII.—Plank Ceilings.

Artificers, Labourers, and Materials, for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Teak planking $\frac{1}{2}$" planed tongued and grooved $5\frac{1}{2}$" clear of tongue R.F.	220	7 0 100 R.F.	15 6			
Screws, brass, $1\frac{1}{4}$" dozen	10	0 2 dozen	1 4			
Sundries	...	.....	0 4			
		Total Materials.	16 14			
Labour.						
Carriage	...	.....	2 0			
Carpenters	2	0 12 each	1 8			
Coolies	2	0 4 do.	0 8			
Sundries	...	.....	0 4			
		Total Labour...	4 4			
Add—						
Varnish 2 coats. S.F...	100	4 12 100	4 12			
Total for 100 Supl. ft. including for varnishing			25 14		Total for 100 Supl. ft. including for varnishing ...	

Note.—$\frac{3}{4}$" teak plank costs about 3/ more per 100 R.F. than $\frac{1}{2}$". $\frac{3}{4}$" deal plank about 2/ less.

XCVIII.—Plank Ceilings, with Joists.

Materials and Labour for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teak wood for frame work ... C. F.	2	3 0 C.F.	6 0			
Teak planking $\frac{1}{2}$″ planed tongued and grooved $5\frac{1}{2}$″ clear of tongue R.F.	220	7 0 100 R.F.	15 6			
Screws, brass, $1\frac{1}{4}$″ dozen.	10	0 2 dozen	1 4			
Sundries	...	.....	0 4			
		Total Materials.	22 14			
Labour.						
On wrought timber C.F.	2	0 6 C.F.	0 12			
On laying planking S. F.	100	2 4 100 S.F.	2 4			
Carriage	...	.....	3 0			
Sundries	...	.....	0 8			
		Total Labour ..	6 8			
Add—			...			
Varnish 2 coats S. F.	100	4 12 100	4 12			
Total for 100 S. F. including Varnishing .			34 12			

XCIX.—Cloth-ceiling.

Artificers, Labourers, and Materials, for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teak for framework C.F.	2	3 0 C.F.	6 0			
Dungree cloth. Supl.ft.	110	3 0 100 Spl.ft.	3 5			
Nails ... ...lbs.	1	1 0 6 lbs.	0 3			
Tacks, tinned ...lbs.	¼	0 4 lbs.	0 1			
Tape ... R. ft.	40	.....	0 2			
Sundries... ...	...	.....	0 4			
		Total Materials.	9 15			
Labour.						
Carpenters	3	0 12 each.	2 4			
Coolies	3	0 3 do.	0 9			
Tailor	¼	0 12 do.	0 3			
Sundries	...	.....	0 4			
		Total Labour...	3 4			
Total for 100 Supl. feet cloth-ceiling...			13 3	Total for 100 Supl. feet cloth-ceiling...		
Add for whitewashing ...			0 8	Add for whitewashing		
Total for 100 Supl. feet including white-washing.			13 11	Total for 100 Supl, feet including white-washing.		

C.—Lath and Plaster Ceilings.

Materials and Labour for 100 Square Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Materials.												
Lime, slaked ... C.F.	20	12	0	40	6	0						
Sand ... ... C.F.	20	2	0	100	0	6						
Bamboos ... No.	54	5	0	100	2	11						
Fuel for straightening Bamboos	...		.....		0	4						
Hemp	...		.....		0	4						
Nails, $1\frac{3}{4}$" long... No,	450	0	2	100	0	9						
Screws, 3" do. ... No.	16	4	0	Gross	0	7						
Sundries	...		.....		0	9						
		Total Materials			11	2						
Labour.												
Carpenters ... No.	6	0	12	each	4	8						
Masons ... No.	8	0	10	do.	5	0						
Coolies... ... No.	8	0	3	do.	1	8						
Bhisties ... No.	1	0	8	do.	0	8						
Scaffolding	...		.....		0	4						
Sundries	...		.....		0	8						
		Total Labour...			12	4						
Total for 100 Square feet ...					23	6						

CI.—Plastering, rough, ¾".

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Lime, slaked ... C. F.	6	12 0 40 C.F.	1 13			
Sand ... ... C. F.	6	2 0 100 C.F.	0 2			
Sundries such as hemp, jágri, &c.	...	... ...	0 5			
		Total Materials.	2 4			
Labour.						
Bricklayers No.	1½	0 10 each.	0 15			
Coolies	1	0 3 do.	0 3			
Women	4	0 2 do.	0 8			
Bhisties	¼	0 8 do.	0 2			
Grinding chunam twice C. F.	6	7 0 100 C.F.	0 7			
Sundries	...	... ...	0 3			
		Total Labour...	2 6			
Total for 100 Supl. Feet...			4 10	Total for 100 Supl. Ft.		

N.B.—For fine coat see next page.

Fine Coat.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime, fine ... C. F.	2	16 0 40 C.F.	0 13			
Sundries	...	... ...	0 2			
		Total Materials.	0 15			
Labour.						
Bricklayers ... No.	1½	0 10 each.	0 15			
Coolies...	1	0 3 do.	0 3			
Women	4	0 2 do.	0 8			
Bhisties	¼	0 8 do.	0 2			
Sundries	...	... ...	0 2			
		Total Labour...	1 14			
Total for 100 Supl. Feet ...			2 13	Total for 100 Spl.feet.		

CII.—Plastering, Rough cast, ½ inch thick.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime, slaked ... C. F.	4	12 0 40 C. F.	1 3			
Gravel, coarse ... C. F.	3	4 0 100 C. F.	0 2			
Lime-screenings C. F.	3	4 0 do.	0 2			
Sundries	...	... ...	0 2			
		Total Materials.	1 9			
Labour.						
Bricklayers No.	¾	0 10 each.	0 8			
Coolies	¾	0 3 do.	0 2			
Women	½	0 2 do.	0 1			
Bhisties	⅛	0 8 do.	0 1			
Sundries	...	... ...	0 2			
		Total Labour.	0 14			
Total for 100 Supl. Feet...			2 7	Total for 100 Supl. Ft.		

CIII.—Brick-rubbed rough Plaster.

This description of work can be done at the rate of about 12 annas per 100 square feet.

CIV.—Cement Plastering.

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Portland Cement, 1 cask or... C. F.	4	10 0 4 C. F.	10 0			
Sand	4	2 0 100 C. F.	0 1			
Sundries	...	... ...	0 4			
		Total Materials.	10 5			
Labour.						
Bricklayers No.	3	0 10 each.	1 14			
Coolies	1	0 3 do.	0 3			
Women	3	0 2 do.	0 6			
Bhisties	¼	0 8 do.	0 2			
Sundries	...	... ...	0 4			
		Total Labour ...	2 13			
		Total for 100 Supl. Feet...	13 2		Total for 100 Supl. Ft.	

CV.—Lime Pointing (Masonry).

Materials and Labour for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate,	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Lime, slaked ... C. F.	1¼	12 0 40 C.F.	0 6			
Sand ... ... C. F.	1¼	2 0 100 C.F.	0 1			
Sundries	...	... ...	0 4			
		Total Materials.	0 11			
Labour.						
Bricklayers ... No.	1½	0 10 each.	0 15			
Women ... No.	2	0 2 do.	0 4			
Bhisties ... No.	¼	0 8 do.	0 2			
Sundries	...	... ...	0 4			
		Total Labour...	1 9			
Total for 100 Square Feet...			2 4			

CVI.—Lime Pointing (Brick-work).

Materials and Labour for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Lime, slaked ... C. F.	2	12 0 40 C.F.	0 9			
Sand ... ... C. F.	2	2 0 100 C.F.	0 1			
Sundries	...	... ...	0 4			
		Total Materials.	0 14			
Labour.						
Bricklayers ... No.	2	0 10 each.	1 4			
Women ... No.	2	0 2 do.	0 4			
Bhisties ... No.	¼	0 8 do.	0 2			
Sundries	...	... ...	0 4			
		Total Labour...	1 14			
Total for 100 Square Feet...			2 12			

CVII.—Cement Pointing,

Artificers, Labourers, and Materials for 100 Supl. Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials						
Portland Cement, ⅛ Cask or C.F.	⅔	10 0 4 C. F.	1 11			
Sand	⅔	2 0 100 C. F.	0 1			
Sundries	...	... ...	0 1			
		Total Materials.	1 13			
Labour.						
Bricklayers No	1½	0 10 each	0 15			
Women	2	0 2 do.	0 4			
Bhisties	⅛	0 8 do.	0 1			
Sundries	...	... ...	0 1			
		Total Labour...	1 5			
		Total for 100 Supl. Feet...	3 2		Total for 100 Supl. Ft.	

VII.—ROOFING SPECIFICATIONS.

		Page.
CVIII.—Double Tiled Roof Covering		170
CIX.— Do. do. do.		170
CX.— Do. do. do.		170
CXI.— Do. do. do.		170
CXII.— Do. do. Roofing xii feet span.	Ordinary construction.	170
CXIII.— Do. do. do. xiv „		170
CXIV.— Do. do. do. xvi „		170
CXV.— Do. do. do. xviii „		170
CXVI.— Do. do. do. xx „		170
CXVII.— Do. do. do. xxii „		170
CXVIII.— Do. do. do. xxiv „		170
CXIX.— Do. do. do. xxvi „		170
CXX.— Do. do. do. xxviii „		170
CXXI.— Do. do. do. xxx „		170
CXXII.— Do. do. Verandah vi „		171
CXXIII.— Do. do. do. viii „		171
CXXIV.— Do. do. do. x „		171
CXXV.— Do. do. Roofing xii „	Purlin rafter construction.	171
CXXVI.— Do. do. do. xiv „		171
CXXVII.— Do. do. do. xvi „		171
CXXVIII.— Do. do. do. xviii „		171
CXXIX.— Do. do. do. xx „		171
CXXX.— Do. do. do. xxii „		171
CXXXI.—Corrugated Iron Roof Covering		172
CXXXII.— Do. do. do.		172
CXXXIII.— Do. do. do.		172
CXXXIV.— Do. do. Roofing xii feet span ...		172
CXXXV.— Do. do. do. xiv „ ...		172
CXXXVI.— Do. do. do. xvi „ ...		172
CXXXVII.— Do. do. do. xviii „ ...		172
CXXXVIII.— Do. do. do. xx „ ...		172
CXXXIX.— Do. do. do. xxii „ ...		172
CXL.—Terraced Roofing viii „ ...		173
CXLI.— Do. do. xii „ ...		173
CXLII.— Do. do. xvi „ ...		173
CXLIII.— Do. do. Fire-proof		174
CXLIV.—Zinc Roof Covering		175
CXLV.—Belgaum Roof Covering		175
CXLVI.—Taylor's Patent Tiles		175
CXLVII.—Mangalore Tiles		177
CXLVIII.—Goodwyn's Tiles		177
CXLIX.—Atkinson's Tiles		177
CL.—Hills' Tiles		178
CLI.—Syrian Roof...		178
CLII.—Wood Cement		178

	Page.
CLIII.—Oropholite	179
CLIV.—Dammering on roof	179
CLV.—Gutters, Valleys, &c.	179
CLVI.— Do. do.	179
CLVII.—Down Pipes	180
CLVIII.—Ridge Ventilators	180
CLIX.—Lightning Conductors	181

VII.—ROOFING SPECIFICATIONS.

1. Specify whether timber is to be wrought, planed, framed, beaded, chamfered, &c.

2. *Unwrought* materials are such as are merely sawn out, but not worked or fitted in any way.

3. *Wrought* materials are those that have been planed, or worked, or fitted in any way.

4. *Framed Work* is when two or more timbers are morticed and tenoned together, or scarfed, such as trusses: but wall plates, or purlins that are merely checked on to each other, are only considered as wrought.

5. The wood-work of roofs should invariably be estimated separately from the covering, as otherwise the rate per square will vary with the length and breadth of every building. The wood-work should include trusses, purlins, wall plates, rafters, &c.

6. A fair rate to take for labour on framed work, is 12 annas per C. F. including fixing in place. For wrought work such as purlins, wall plates, &c., 6 annas per C. F. will suffice.

7. To find out a rate for a total quantity of 100 C. F. of timber in roof take as follows:—

Materials and Labour.	No. or quantity.	Rate.	Amount.	No. or quantity.	Rate.	Amount.
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay .. .. .. C. F.	100	3 0 C. F.	300 0			
Iron work in trusses, &c. Cwt.	1	21 0 Cwt.	21 0			
Nails for Purlin blocks, &c. Cwt.	½	14 0 Cwt.	7 0			
Sundries	..	....	2 8			
Labour.						
On framed timber .. .. C. F.	25	0 12 C. F.	18 12			
On wrought timber .. C. F.	75	0 6 C. F.	28 2			
On fitting iron-work	..	....	7 0			
Carriage of timber .. .. C. F.	100	0 4 C. F.	25 0			
Sundrie	..	....	2 8			
		For 100 C. F. of timber ..	411 14		For 100 C. F. of timber.	
		Or per C. F. very nearly ..	4 2		Or per C. F. very nearly.	

Enter in abstract of Estimate 100 C. F. of teak at Rs. 4-2-0 per C. F.

8. To find a rate for double tiled roofing for example, work out the quantities of wood-work, double tiling, ridges and hips, eaves, and eaves board as follows :—

Labourers and Materials for Superficial Feet of Roofing.	No. or quantity.	Rate.	Amount.	No. or quantity.	Rate.	Amount.
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Wood-work .. .. ..C. F.						
Double tiling.. .. ..S. F.						
Setting ridges and hips in chunam .. ..R. F.						
Setting double eaves in chunam .. ..R. F.						
Eaves board .. .. ..R. F.						
Total for S. F. of roof-covering completed .. Or for 100 S. F. of do. ..				Total for S. F. of roof covering completed .. .. Or for 100 S. F. of do.		

CVIII to CXI.—Double Tiled Roof Covering.

Tiles. 1. To be of sound, well burnt tiles 10″ × 3¼″, free from flaws and defects, and fitting about 3″ into one another.

Hips, ridges, and eaves. 2. The eaves to be set in mortar. The ridges and hips to be of ridge tiles carefully set in mortar, but not plastered.

Soaking. 3. All tiles to be soaked for 12 hours before use, in water mixed with cowdung, before being used on the work.

Battens. 4. The battens to be of sawn teak scantlings 2″ × ½″ placed 2 inches clear distance apart.

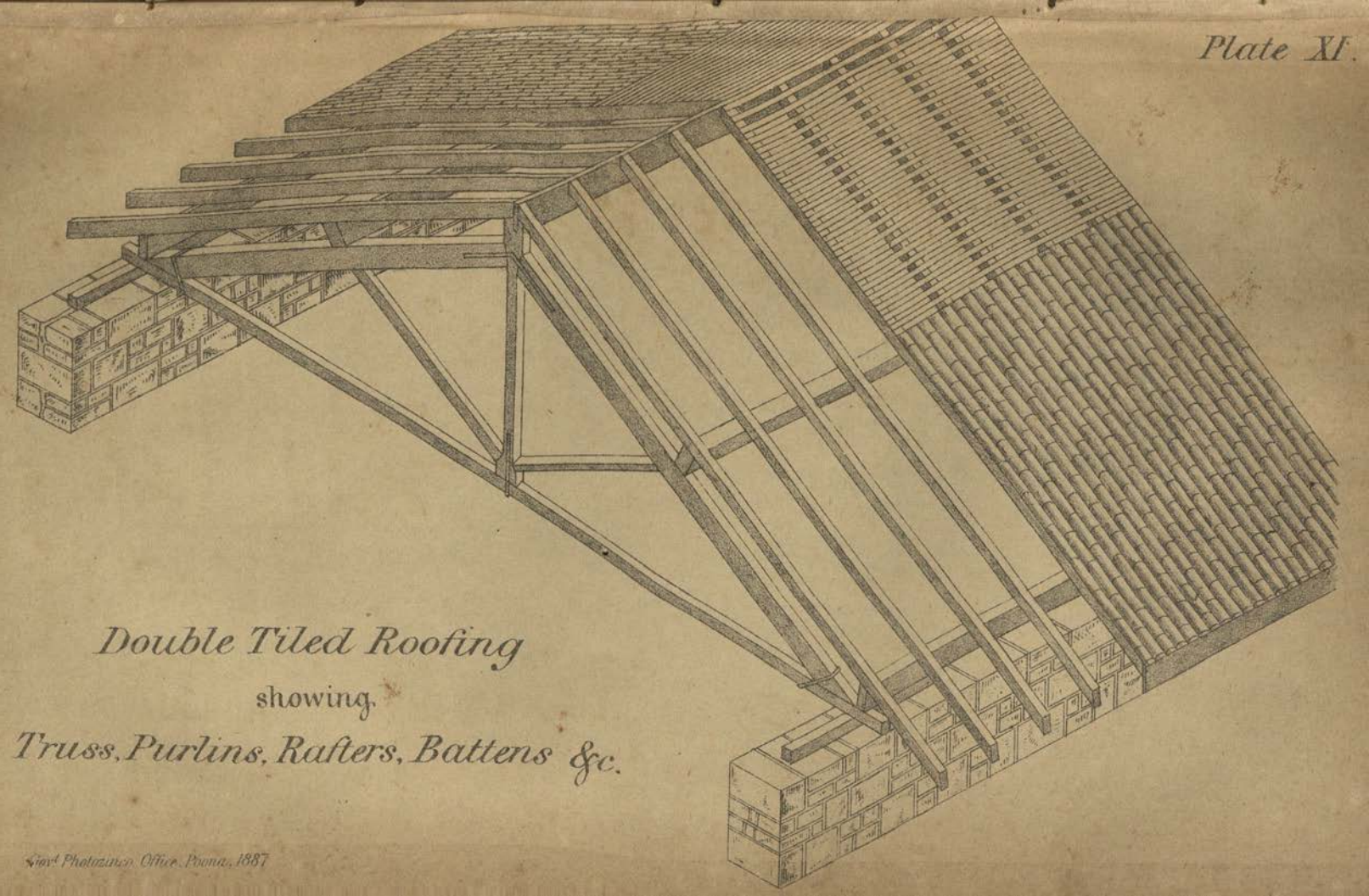
CXII to CXXI.—Double Tiled Roofing—(Ordinary Construction).

Roof covering. 1. Roof covering to be as specified in Nos. CVIII to CXI above.

Wood-work. 2. All wood-work to be of well-seasoned Moulmein Teak, neatly planed, varnished or painted, and in other respects as specified for wood-work, in general (Specification No. XXIV). The unexposed portions of the timber to be worked smooth, but not planed.

Trusses. 3. The trusses to be constructed in accordance with the drawings furnished; all mortice and tenon joints, scarfs, &c., to be fitted together accurately in a workmanlike manner. The scantlings of the different parts, unless otherwise specified, to be in accordance with those given in Tables XVII and XVIII. To be placed at 10 feet central distance

Plate XI.

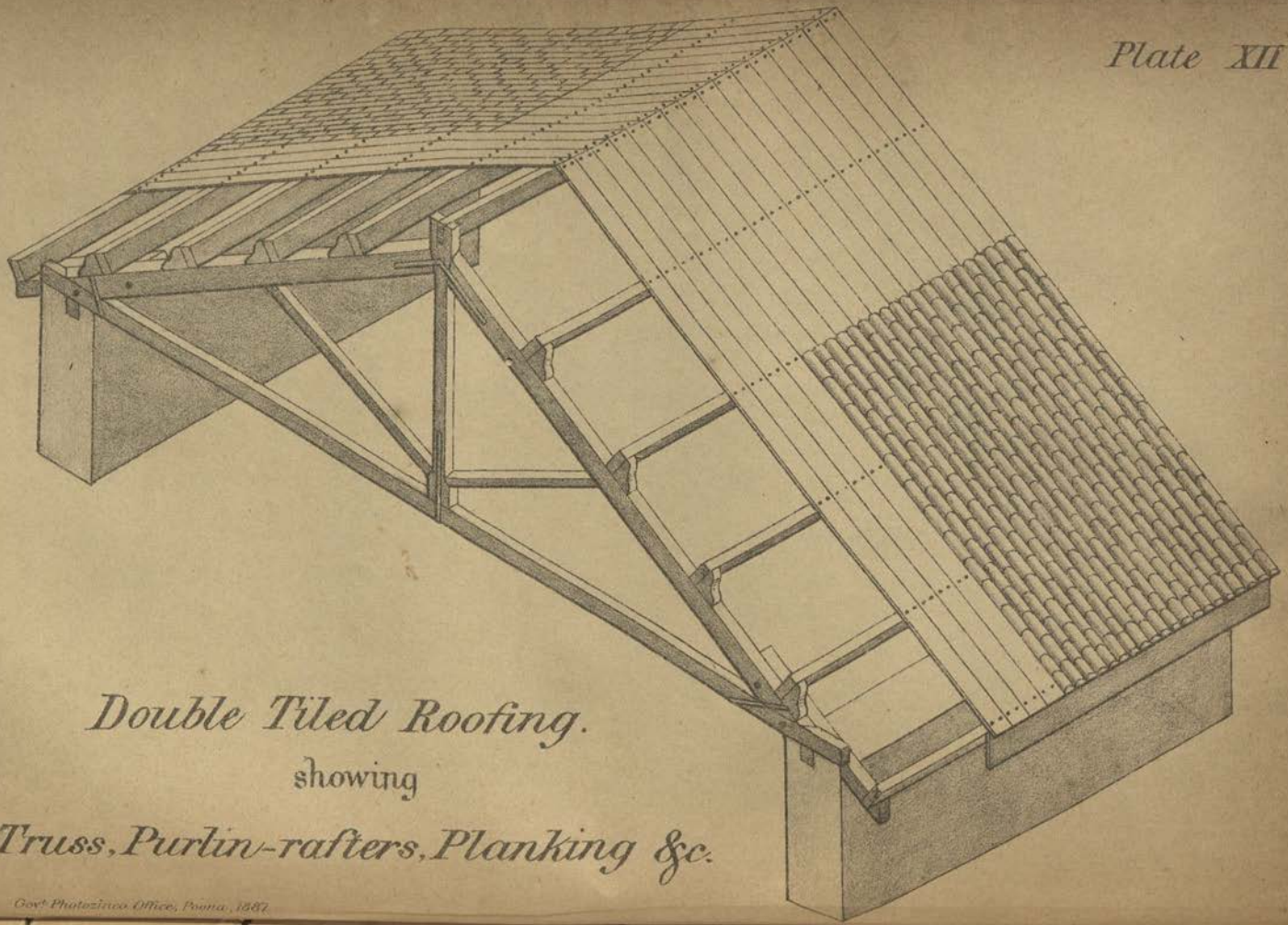


Double Tiled Roofing

showing

Truss, Purlins, Rafters, Battens &c.

Govt. Photozinco. Office, Poona. 1887



Double Tiled Roofing.

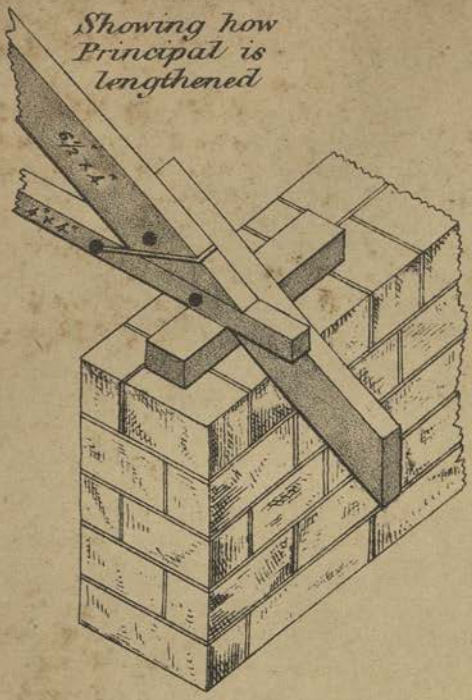
showing

Truss, Purlin-rafters, Planking &c.

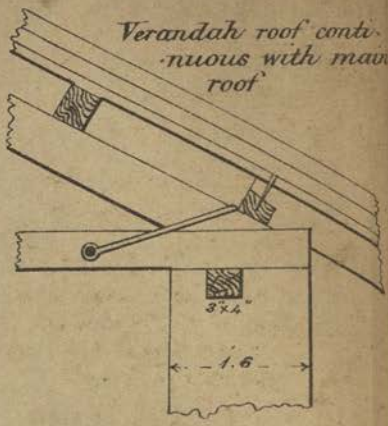
Govt. Photozinco Office, Poona, 1887.

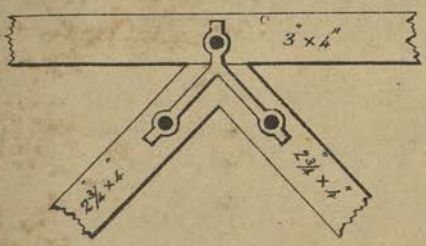
Purlin Roof.

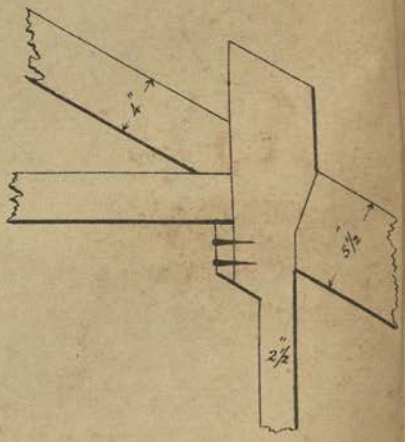
Showing how Principal is lengthened

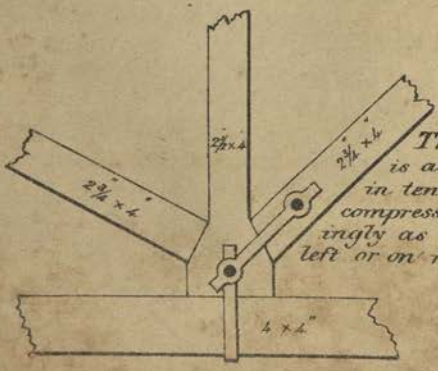


Verandah roof continuous with main roof

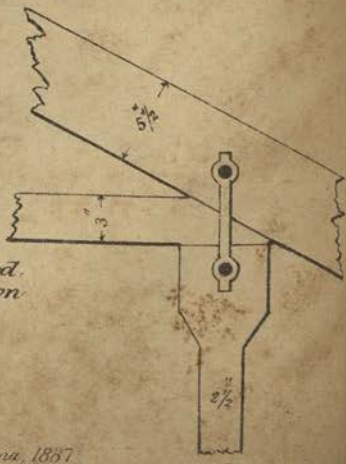








This piece is alternately in tension and compression accordingly as wind is on left or on right.



Govt Photozinco Office, Poona, 1887

apart, their ends well tarred, bearing on stone bed plates or wooden templates.

Purlins, common Rafters, &c.

4. Purlins, common rafters, &c., to be of the scantlings given in Table XVIII. Purlins to be in the greatest lengths procurable, and to be scarfed together, wherever necessary, immediately above the principal rafter of the truss on which the ends rest, and to be secured in position by purlin blocks. Common rafters to be fixed at central distances apart not exceeding 18 inches, and to be in continuous lengths from ridge to eaves (wherever possible), notched to fit the purlin, with their lower ends notched and nailed to wall plates.

Iron-work.

5. All iron straps, bolts, &c., used in the work to be of good workmanship, and to be dipped in common Teel oil while red-hot.

CXXII to CXXIV.—Double Tiled Verandah Roofing.

Roof Covering.

1. Roof covering to be as specified in Nos. CVIII to CXI above.

Principals and purlins.

2. Principal rafters carrying a purlin to be placed at central distances of 8 to 10 feet apart in all cases when the clear width of the verandah exceeds 8 feet.

Common Rafters.

3. The tops of the common rafters to be secured to wall plates laid in the wall, and on no account to be merely built into it.

CXXV to CXXX.—Double Tiled Roofing—(Purlin-rafter Construction).

Description.

1. This description of roofing will correspond generally to that described in Nos. CXII to CXXI above, differing from it, however, in the following respects.

Lengthening piece.

2. The principal rafter to be prolonged to the eaves by the addition of a piece of timber of the same scantling bolted to its side and to the tie-beam as shown in drawing, to carry the purlin rafter at the eaves.

Purlin rafters.

3. A series of purlin rafters $3\frac{1}{2}'' \times 5\frac{1}{4}''$ placed at central distances of about 3 feet apart to be laid on the principal rafters of the trusses (similar to ordinary purlins) secured to them in the usual way, and to be in length not less than double the distance at which the trusses are set apart.

Teak planking.

4. Teak planking $\frac{3}{4}$ inch thick, tongued and grooved, to be laid on these purlin rafters continuously from ridge to eaves in lieu of battens.

5. The tiles to be laid in the ordinary way on the planking, which latter, however, should be omitted over the walls, and the tiles there "set" in mortar to prevent them slipping.

Tiling.

Note.—The purlin rafters may be set, if desired, at central distances of 2 feet apart. In that case their scantling should be $3\frac{1}{2}'' \times 4\frac{3}{4}''$. The cost of the roof would, however, be more than if placed 3 feet apart, and of the scantling specified in para. 3 above.

CXXXI. to CXXXIII.—Galvanized, Corrugated Iron Roof Covering.

1. To be of sound, galvanized, corrugated iron of 20, 18, or 16 B. W. G. as may be specified, uninjured in the carriage by the rubbing of the zinc covering, or otherwise.

Gauge.

2. The sheets to be laid with laps of 6″ at the ends and 2 corrugations at the sides, and vertical laps to be turned away from the rainy quarter.

Laps.

3. The holes for the rivets are to be drilled (not punched) from the inside towards the outside, at a distance of about 9″ apart on the sides, and every second corrugation on the ends.

Drillings.

4. The sheets when so fastened with the best galvanized rivets and lead washers are to be set carefully on the purlins, and fastened to them by Allen's or other approved fasteners, galvanized iron screws and washers, or by bolts, as may be shown in the drawings.

Fastening down.

These bolts to be placed 5 feet horizontally and in the same line in the direction of the slope over each purlin, care being taken in the case of rivets and bolts that the holes to receive them are drilled in the *ridge* of the corrugation.

5. Ridges and hips to be of neat zinc, 20 B. W. G., with a foot lap on each side securely fastened down so as to prevent the rain driving under it.

Ridges.

Note.—In open sheds or verandahs where wind can get under the roof, it is absolutely necessary to fasten down the plates by continuous lengths of wrought iron about $2'' \times \frac{1}{4}''$ bolted through the purlins, and also to secure the purlins by bolting them down to the masonry or other posts.

CXXXIV to CXXXIX.—Corrugated Iron Roofing. 20 B. W. G.

1. Roof covering to be as specified in Nos. CXXXI to CXXXIII above.

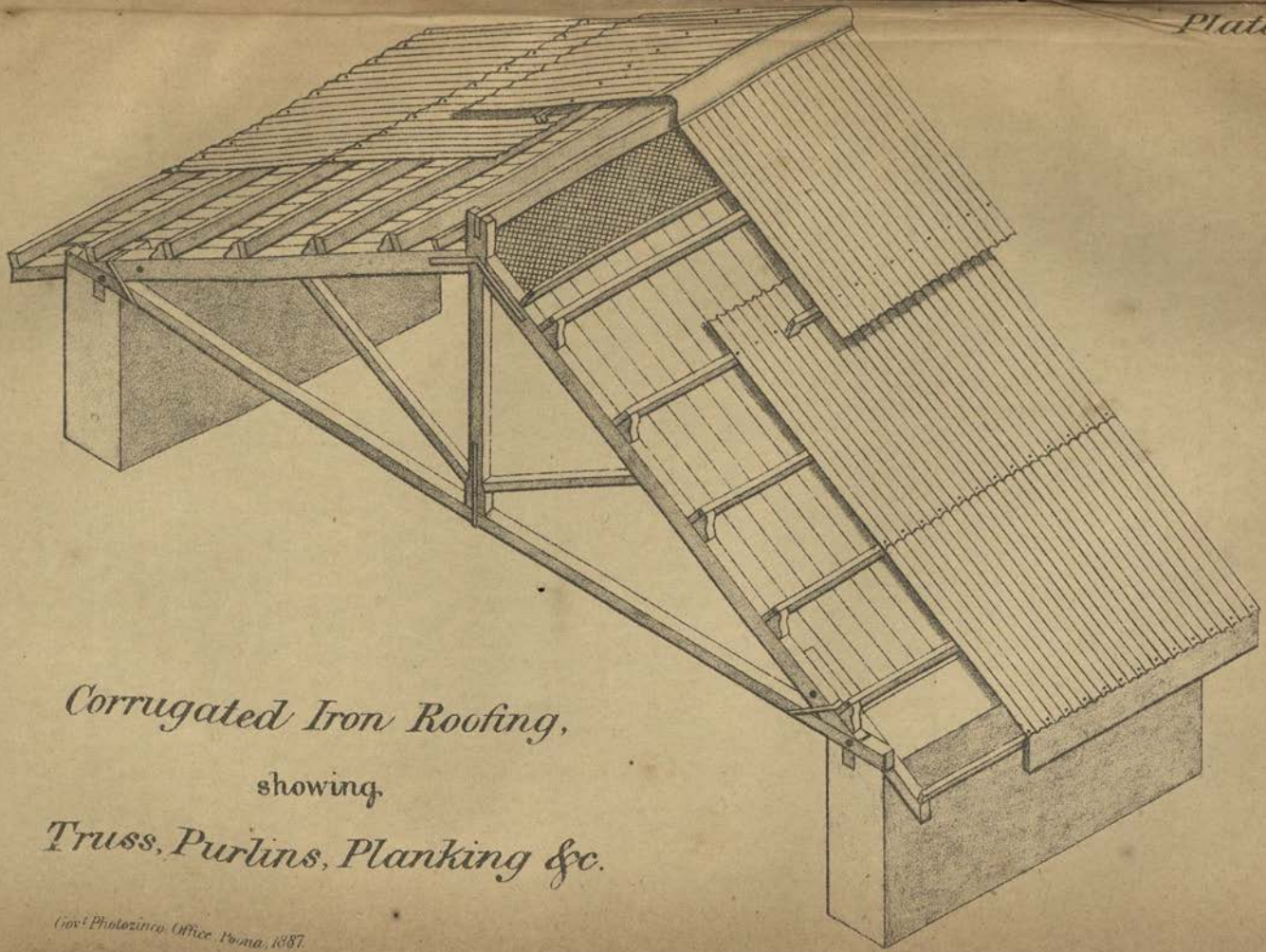
Roof covering.

2. The sheeting to be supported on teak purlins and trusses, (which will accord generally with the conditions laid down in Specification No. CXII above), in the manner described below.

Timber frame work.

3. A series of longitudinal purlins will be placed at central distances apart of about 3 feet, or of half of the length of each riveted sheet. On these

Purlins.



Corrugated Iron Roofing,

showing

Truss, Purlins, Planking &c.

Govt Photozinco Office Poona, 1887.

the corrugated-iron sheeting will be laid, the overlapping and riveted ends of the sheets being secured to each *alternate* purlin by 3″ galvanized iron screws and washers about 6 inches apart.

Teak planking.

4. Teak planking ½″ thick, tongued and grooved, will then be screwed to the *under side* of the purlins, extending from under ridge to walls, leaving thus an air chamber of the full depth of the purlins between the planking and roof covering above.

Galvanized wire netting.

5. When Howard's or any other ridge ventilator is used, as is very desirable with an iron roof, the planking will finish at each side of the double ridge and the open space left be filled in with galvanized wire netting; when no separate ridge ventilator is used, holes 1″ diameter should be cut in the planking along the ridge at each side, whereby some ventilation is ensured through the spaces between the corrugated iron sheets and the plane ridge capping; also in any case holes 1″ diameter should be cut in the planking along the walls, so as to set up a current of air between the planking and the iron sheeting.

6. Eaves gutters to be provided.

CXL to CXLII.—Terraced Roofing.

Description.

1. To consist of one layer of flat tiles soaked in thick whitewash set in lime mortar over 3 inches of fine concrete placed on two layers of flat tiles also set in mortar, the whole supported on teak scantlings placed one foot apart.

Flat tiles.

2. The lower layer of flat tiles to measure 12″ × 6″ × 1″ and to be laid in two courses one above the other, breaking joint with another. Both layers to be laid with their sides well rubbed and drawn up with mortar. The upper layer to be embedded in mortar on the lower.

Concrete.

3. The concrete to be prepared in accordance with Specification No. LVII., and to consist of lime, clean sharp sand, and screened shingle in the proportions therein named. After the concrete has been spread it will be wetted and beaten with light quick strokes with a hand flail till the mortar is drawn up to the surface and the mass is well set.

Upper layer of tiles.

4. Covering the concrete a layer of tiles similar to those described in paragraph 2 will then be set. The tiles to be well soaked in thick whitewash, their sides rubbed and drawn up with mortar as above described.

Joists and wall plates.

5. The whole to be supported on teak joists placed at central distances of 12 inches apart, and to be of the scantlings given in the foot-notes of the rates Nos. CXL to CXLII, unless otherwise specified. The joists to rest on wall plates 4″ × 3½″ built into the wall, or on corbels outside it.

Slope. 6. The roof to be laid with a slope of about ½ inch to a foot to prevent rain water lodging upon it.

String course. 7. At the junction of the roof covering with any wall a string course projecting not less than 4 inches to be built into the wall at a height of 2 inches above the upper surface of the roof, and the intervening space to be carefully filled in with concrete to prevent leakage down the wall.

CXLIII.—Fire-proof Terraced Roofing.

Description. 1. The roofing to consist of 4 inches of ordinary concrete resting on a layer of paving bricks 1½ to 2 inches thick, supported on tee iron joists and rolled iron beams, as described below.

Rolled Iron Beams. 2. The rolled iron beams to be of the dimensions laid down and to be laid at central distances of 4 feet apart. The ends of these beams to be built into the walls, and to rest on bed plates of ¼ inch boiler plate iron, 18 inches long and 9 inches broad.

Tee Iron joists. 3. The tee iron joists to measure $2'' \times 2'' \times \frac{1}{4}''$ in all cases, and to be laid (flange downwards) on the rolled iron beams above alluded to at central distances of 12½ inches apart. The continuous lengths of these joists to be secured together by means of U shaped clips of boiler plate iron 1½ inches broad and ¼ inch thick hammered over them to keep them in position.

Paving Bricks. 4. The spaces between the tee iron joist to be filled in with a single layer of sound, well burnt paving bricks one foot square and 1½ to 2 inches thick, set in Portland cement mortar or with two courses of flat tiles measuring $12'' \times 6'' \times 1''$, one above the other, breaking joint with one another. In either case to be laid with the smooth face downwards, pointed from below, and their sides well rubbed and drawn up with mortar as above.

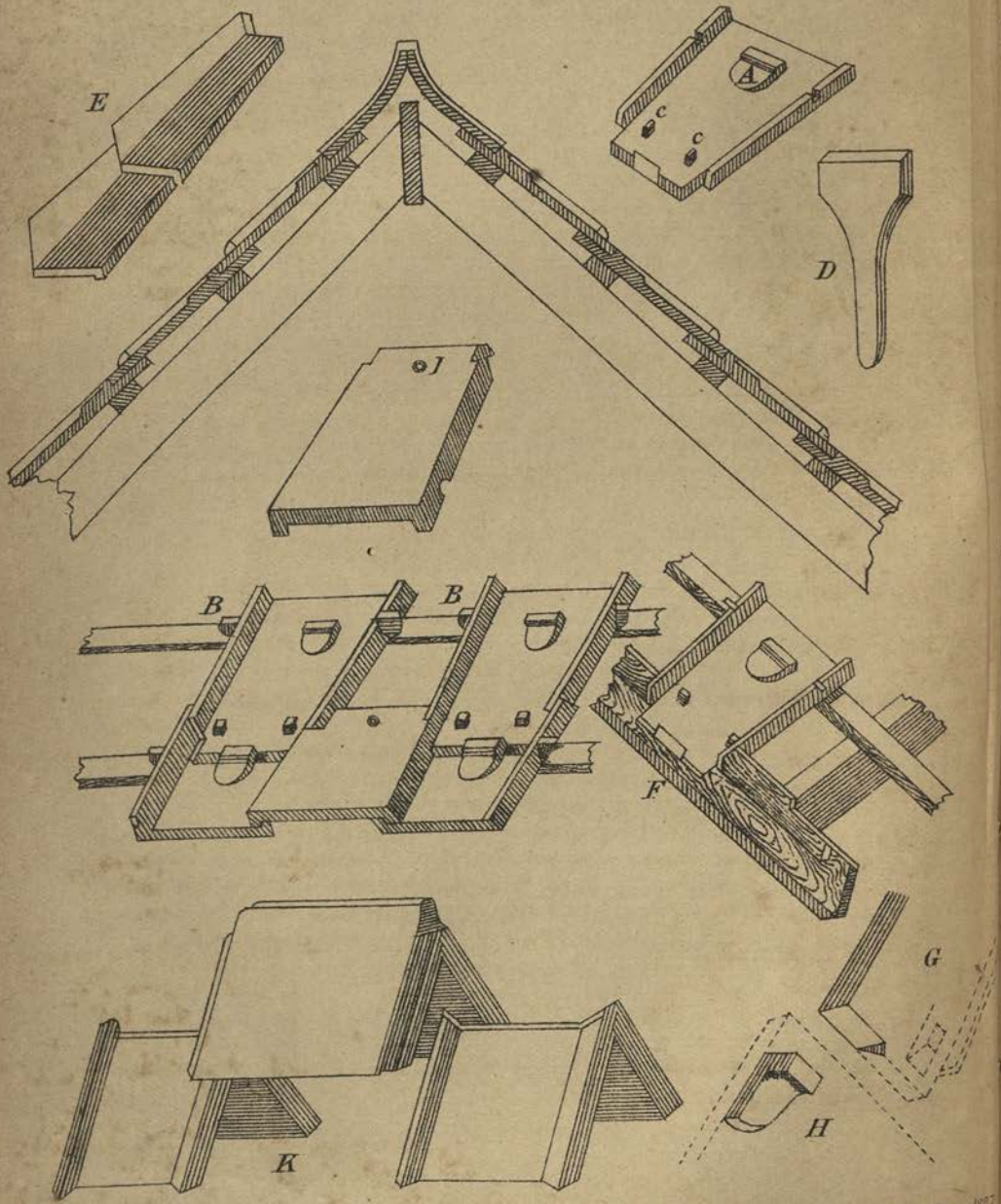
Concrete. 5. Concrete to consist of 1 part slaked lime, 2 parts sand, and 5 parts screened shingle, and to be prepared in accordance with specification No. LVII. The upper surface to be finished off with a half inch coat of Portland cement plaster. After the concrete has been spread it will be wetted and beaten with light rammers, or hand flails, till the mortar is drawn up to the surface and the mass is well set.

Slope. 6. The roof to be laid with a slope of about ½ inch to a foot to prevent rain water lodging upon it.

String Course. 7. At the junction of the roof covering with any wall a string course projecting not less than 4 inches to be built into the wall at a height of 2 inches above

Taylor's Patent Tiles.

A Section through the Roof & a few tiles, a nail, two hip-tiles &c.



Govt Photozinco: Office, Poona. 1887.

the upper surface of the roof, and the intervening space to be carefully filled in with concrete to prevent leakage down the wall.

8. All iron work to be properly cleaned and then painted with one coat of red lead, to be included in the rate. The under surface of the roof to be painted with two coats of the colour and description ordered.

Painting.

9. The beams to be cambered to a rise of about 1 inch in 15 feet, to be included in the price, and to be shored up from below while the concrete is being laid and rammed.

Camber.

CXLIV.—Zinc Roof Covering.

To be of 20, 19, or 18 B. W. gauge, "Italian corrugation", screwed to wooden rolls with patent embossed holes and screws, the screw not to penetrate both sheets at the lap. The horizontal joints to be made by folding laps secured by clips 2″ wide placed apart; care must be taken to give every facility to the zinc for expansion and contraction.

Note.—In Bombay zinc roofing has been found unsuitable to the climate, owing to its very great expansion and contraction.

CXLV.—Belgaum Roof Covering.

Consists of a layer of small flat tiles about $5'' \times 5'' \times \frac{1}{2}''$, with edges rubbed to make close joints, and soaked in *pure white* lime of about the consistency of cream, laid in mortar on sawn teak battens $2'' \times \frac{1}{2}''$ placed 3″ apart; over them a $\frac{1}{2}''$ layer of mortar and then a layer of ordinary native semi-cylindrical tiles about $14'' \times 5''$ is laid, eaves and ridges set in mortar.

Note.—This makes a very nice roof.

CXLVI.—Taylor's Patent Tiles.

1. The battens are laid to about 10″ gauge, size $3'' \times 1''$ or $\frac{3}{4}''$, the width being required to enable the upper tile it bears to be nailed as described in paragraph 4.

Battens.

2. Before nailing the battens to the rafters, arrange on the roof one row of channel tiles from eaves to ridge, fitting the narrow end of one into the wide end of the other, the shield A (see Plate XIV) on the tile being uppermost, the centre of which should be $\frac{3}{4}''$ above the nail nitch, in the flanges as at B. Then take a row up the opposite side in the same way, the tiles on either side of the ridge to be left about 8″ apart measured horizontally at the upper part of shield A. (Try ridge tile before nailing roof tiles.) Should this not be exact, the eaves tiles may project a little more or less; or, should the difference be greater, the shield may be cut off from channel tiles next the ridge, which will then adapt itself. Having thus obtained the gauge, nail the battens securely. It is of importance that they should all be of the same thickness.

Fixing battens.

3. Arrange the tiles along the whole length of the rule so as to determine whether the ends shall finish with a row of under or upper tiles (the latter is preferable). If the finish is made with the upper tiles they should rest upon an $1\frac{1}{4}''$ batten laid right up the roof just within the stop C nearest to the outer ridge of the tile. The tiles should project a little over. If the finish is made with the under tiles, the batten is not required.

Ends.

Fixing tiles on roof.

4. Commence at the eaves with channel tiles and lay them to a line to the ridge fitting the narrow end of the one tile into the wide end of the next, shield A being uppermost, the wide end of the tile just touching the line, which must be perfectly square to the ridge. Arrange in like manner the next row of channel tiles, carefully leaving between them the exact space required for upper tiles, then nail the channel tiles with the patent wedge-shaped nail D, driven into the batten at the nitches on each side of the tile as at B, taking care to drive the nail in, at right angles to the batten.

Under or Channel Tiles.

5. The space between the two rows of channel tiles to be capped by a tile turned the reverse way to the channel tile, viz., wide end down, plain side uppermost, its flanges capping over the up-turned flanges of the channel tile, the two small blocks C.C. at narrow end of tile resting on the patent nails as at B. The rest of the upper tiles will follow in the same manner, forming a $2\frac{1}{2}''$ lap over the upper tile beneath it, and should be gently wedged down so that the splay as at G, at the narrow end of the tile beneath it, shall securely dovetail into the undercut, the shield of the tile being wedged as at H. In no case should the tiles be laid so far apart as to require cutting or chipping.

Upper or Capping Tiles.

6. The upper tiles should be drilled as at I., 1″ from the edge in the middle of the narrow end of the tile and be nailed to the batten with a $2\frac{1}{2}''$ galvanised nail.

Drilling and Nailing Upper Tiles.

7. Consist of an upper ridge tile with flange turned downwards, capping over the under-ridge tiles with flanges turned upwards, the under ridge being placed upon the channel tiles. The ridge should be bedded in mortar and pointed with cement.

Ridge Tiles as at K.

8. The roof tiles to be cut to the hip tiles, and the latter to be set in mortar and cement pointed.

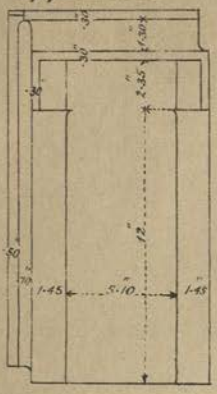
Hip Tiles as at E.

9. A thin batten should be scribed to the underside of the tile to fill up the vacuum under the upper tiles; the board to be nailed on the usual facial board or rafter feet.

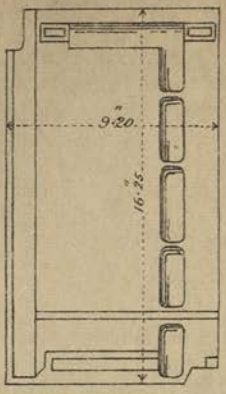
Finish at eaves as at F.

Mangalore Tiles.

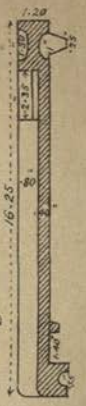
Upper Side



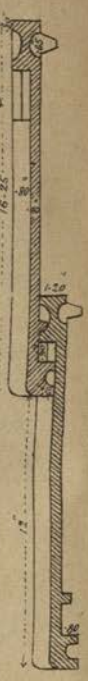
Lower Side



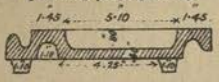
Longitudinal Section



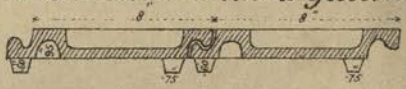
Longitudinal Section when adjusted



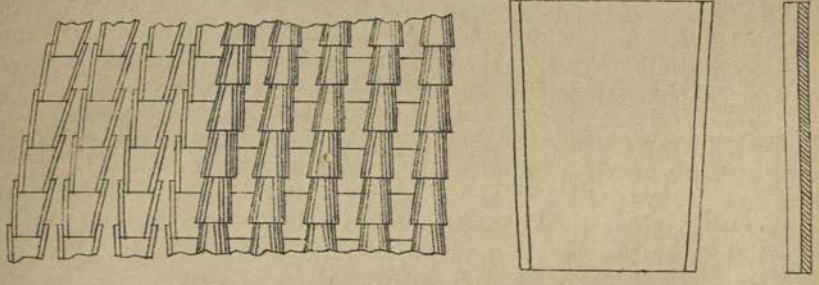
Cross Section



Cross Section when adjusted

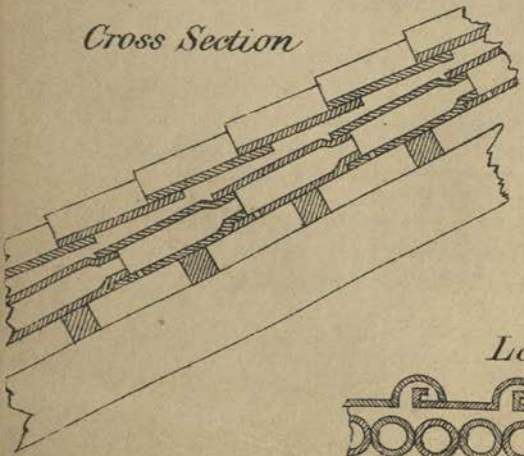


Goodwyn's Tiles.

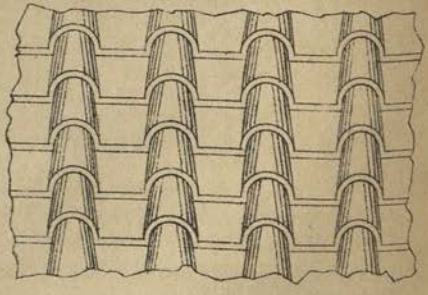


Atkinson's Tiles.

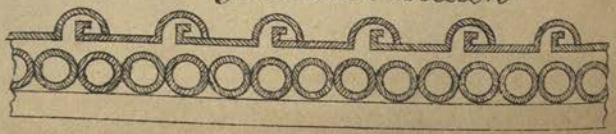
Cross Section



Elevation



Longitudinal Section



Phoenix Office, Poona. 1887.

Valleys. 10. To be of lead or zinc as in No. CLV, to which the roof tiles will be cut.

CXLVII.—Mangalore Tiles, patent.

Laid single as per sketch (see Plate XV) on battens 1″ × 1¾″ and 12½″ from centre to centre. Ridge, hips, &c., set in mortar.

CXLVIII.—Goodwyn's Tiles.

Are generally laid as follows:—

Flat Tiles. 1. A layer of flat square tiles 12″ square and 1″ thick, made of well-tempered clay thoroughly burnt, not vitrified, without flaws or twists, sound, of regular shape, with sharp square edges and ringing well, is laid with close joints not exceeding $\frac{3}{16}$″ in thickness in mortar on battens 3″ × 2″ and 12″ from centre to centre nailed on to purlins. (When more than one course is laid, the second layer breaks joint with the first, and has not less than ½″ mortar between them).

Upper Tiles. 2. On this 1½″ of mortar is laid, in which Goodwyn's tiles are well embedded at regular intervals, the spaces between them being filled up with mortar.

CXLIX.—Atkinson's Tiles.

Cylindrical Tiles. 1. This pattern consists of two layers of tiles, the upper being Italian pantiles laid in mortar over cylindrical tiles. The cylindrical tiles to be 12″ long, 4″ external diameter and ½″ thick, fitting ½″ into each other with a shoulder and socket joint, a lip to rest on the battens to be raised on it ½″ from the shoulder, 2 holes of ½″ diameter to be pierced through the tile in lime with the lip which is on the lower side of the tile. The tiles to be moulded of well-tempered clay, thoroughly burnt, sound, and of true shape without taper.

These cylindrical tiles are to be laid close with their axes up the slope of the roof, and covered with 3″ of mortar and in this, while wet, will be laid Italian pantiles.

Pantiles. 2. The pantiles are to be 12″ long and 12″ wide over all, and not less than ½″ thick, of well-tempered clay, thoroughly burnt, free from twists, sound, and firm, and of uniform size and shape.

The mortar in which the tiles are laid is to be drawn up, so as to fill the curved roll which overlaps at the vertical joint.

The lower edge of each pantile to overlap 3″ the tile below it, a lip to be raised on the under side of each tile to rest against the lower tile and prevent slipping.

See diagrams Plate XV.

CL.—Hills' Tiles.

1. Proposes to lay them single or double, or the reverse way to Goodwyn's, *i.e.* the flat tiles to be set in mortar on the top of the semi-hexagonal tiles in two layers, over which ½″ of plaster is to be laid, so that birds, &c., cannot displace the tiles, and soldiers throwing stones will not injure the roof.

CLI.—Syrian Roof as used in Sind.

1. Is formed of hollow hexagonal tiles which form a vault.

2. The haunches and end walls having been carried up to the requisite height, the 1st voussoir is let into the end wall at the crown of the curve, other voussoirs at proper intervals are then similarly let into the wall till the haunches are reached. About half of each voussoir ought to project outside the wall, and the intervals between each should be sufficiently large for the reception of half a voussoir and its cement. The vaulting is then commenced at the angles, which are gradually filled in, each course of voussoirs being commenced at the end wall, and carried obliquely down to the haunch in the order they are numbered in the sketch.

Fixing Voussoirs.

The sides of voussoirs 6 and 7 and the wall in front being covered with cement, No. 8 is thrust in, care being taken to keep the top parallel to the direction of the vault.

3. The vault is kept in the proper curve by a circular piece of plank standing on the projecting bricks of the cornice, no centering being required. Mud and bhoosa is the cement generally used, and has been found quite sufficient. It requires plastering outside and plastering or pointing inside.

Centering.

CLII.—Wood Cement.

Said to be much used in parts of Germany.

Slope. 1. Slope of roof to be at least ¾″ per foot.

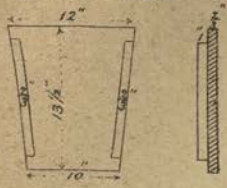
Planking. 2. 1″ planking tongued and grooved is nailed to joists and covered with a layer of sand ½″ thick.

Paper. 3. Strong brown paper in continuous rolls and as broad as possible, is then laid on this, each length overlapping the next by at least 4″.

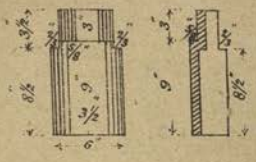
Ingredients. 4. Mix the ingredients in proportion of 100 lbs. tar to 180 lbs. Portland cement into an iron cauldron and heat, care being taken to heat the tar gently and mix the Portland cement with it gradually, in order to prevent its boiling over (1 lb. of powdered sulphur to every cwt. of P. C. is said to improve the mixture). This mixture must then be laid as

Hill's Tiles

Lower Tile



Upper Tile

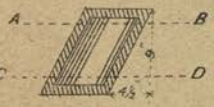


Single Tiles with double layer of flat tiles & terrace.

Double Tiles.

Syrian Roof

Section of Hollow Voussoir

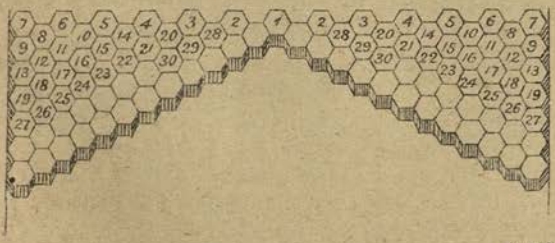


Section A. B.

Section C. D.

Developed Plan of Vault in course of construction.

End Wall



Govt. Photozinco. Office. Penna. 1887

hot as possible on the paper with a tar brush. The next layer of paper is then laid upon it, breaking joint with the last layer and smoothed with a light wooden roller. The 3rd and 4th layers are in like manner laid with alternate layers of wood, cement and paper. The last layer must be carefully covered with cement and then strewed with sifted ashes $\frac{1}{4}''$ thick.

Finishing.

5. The whole is then finished with a coating of sifted gravel containing about $\frac{1}{3}$ of dry loam truly levelled with rakes and scrapers.

Note.—Said to be cool, durable, and not affected by the sun.
May be covered with earth and used as gardens without injury.
Fresh cement is most suitable.
The mixture is improved by keeping and re-melting.

CLIII.—Oropholite.

Ingredients.

1. Is made of sharp river sand and chalk, with an admixture of litharge, all finely sifted and made into a paste with linseed oil.

Cloth.

2. This is spread on one or both sides of any kind of common coarse cloth, so as to form, when dry, a sheet about $\frac{3}{8}''$ thick. The sheets when prepared are hung up to dry, and are then applied in pieces of such size as may be convenient.

CLIV.—Dammering on Roof.

A coat of melted pitch is to be applied to the upper surface of the boarding; on this, before it hardens, tack down old tarpaulins smoothly and carefully laid with proper laps. On this another coat of pitch, with a smaller quantity of tar to take away its brittleness, mixed in it, is to be carefully laid on, thoroughly spread and well worked in.

CLV. and CLVI.—Gutters, Valleys and Flashings.

Fall.

1. Gutters should have a fall of at least $1''$ in $10'$, more being always given if possible.

Valleys.

2. To consist of $1''$ teak planking supported on bearers properly fastened to the rafters, not less than $6''$ wide at bottom and turned up under the tiles $12''$ on each side covered with (*a*) good milled lead not less than 6 lbs. to the square foot; (*b*), or sheet zinc, 18 or 19 B. W. G. copper nails to be used in fastening lead to wood-work; (*c*), or sheet iron not less than $\frac{1}{16}''$ thick bent to the shape required properly secured to the boarding.

Boarding to be well dammered before lead, &c., is applied.

Flashings.

3. To be of 5 lbs. milled or lead 18 B. W. G. zinc, if possible built into the wall, or otherwise to be fastened into a groove $\frac{3}{4}''$ deep with wall hooks and Portland cement.

CLVII.—Down Pipes.

1. Down pipes of cast iron are costly and heavy. As a rule they will be made of sheet iron bent on a cylindrical core diameter and carefully rivetted together, the sides having a lap of $\frac{5}{8}$″ beyond the rivet heads. The ends of the various lengths will butt firmly upon each other, and will be joined together by a collar of the same material, at least 6″ long, which will first be rivetted together and then shrunk on. They shall be firmly secured to the wall by semicircular collars with flanges and flat nails 6″ long at intervals of not more than 6′ joints to be made perfectly water-tight.

Sheet iron.

2. If sheet iron is not galvanized, it shall receive at least 3 coats of paint internally and externally.

Painting.

CLVIII.—Ridge Ventilator (Howard's Pattern).

1. Two ridge poles of suitable dimensions to be provided one on either side of the head of the king post, with a clear space of 6″ intervening between them.

Ridge poles.

2. This space will be preserved by means of cleats placed at intervals of 3′ or 4′ along the length of the ridge. The space between the two ridge poles forms an exit for foul air.

Ventilating space.

3. To form a covering to protect the space, and at the same time to allow of the escape of the foul air, the vertical limbs of two light cast iron brackets are secured to the inner face of either ridge pole at the points where the cleats, above mentioned, occur. Two bolts are passed through the ridge poles, brackets and cleats, thus securing them in their proper places.

Cast iron brackets.

4. The sloping limb of the cast iron bracket, which has the same angle as the roof depends over the main roof, so forming a line of supports for the ridge covering.

Slope.

5. The most durable and economical material for the ridge covering is corrugated iron. Two battens 3″ × $1\frac{1}{4}$″ on either bracket, together with a ridge piece is all the wood work that is necessary. The corrugated iron is bolted to the bracket, the bolt passing through the battens. (See Plate XVII.)

Ventilator covering.

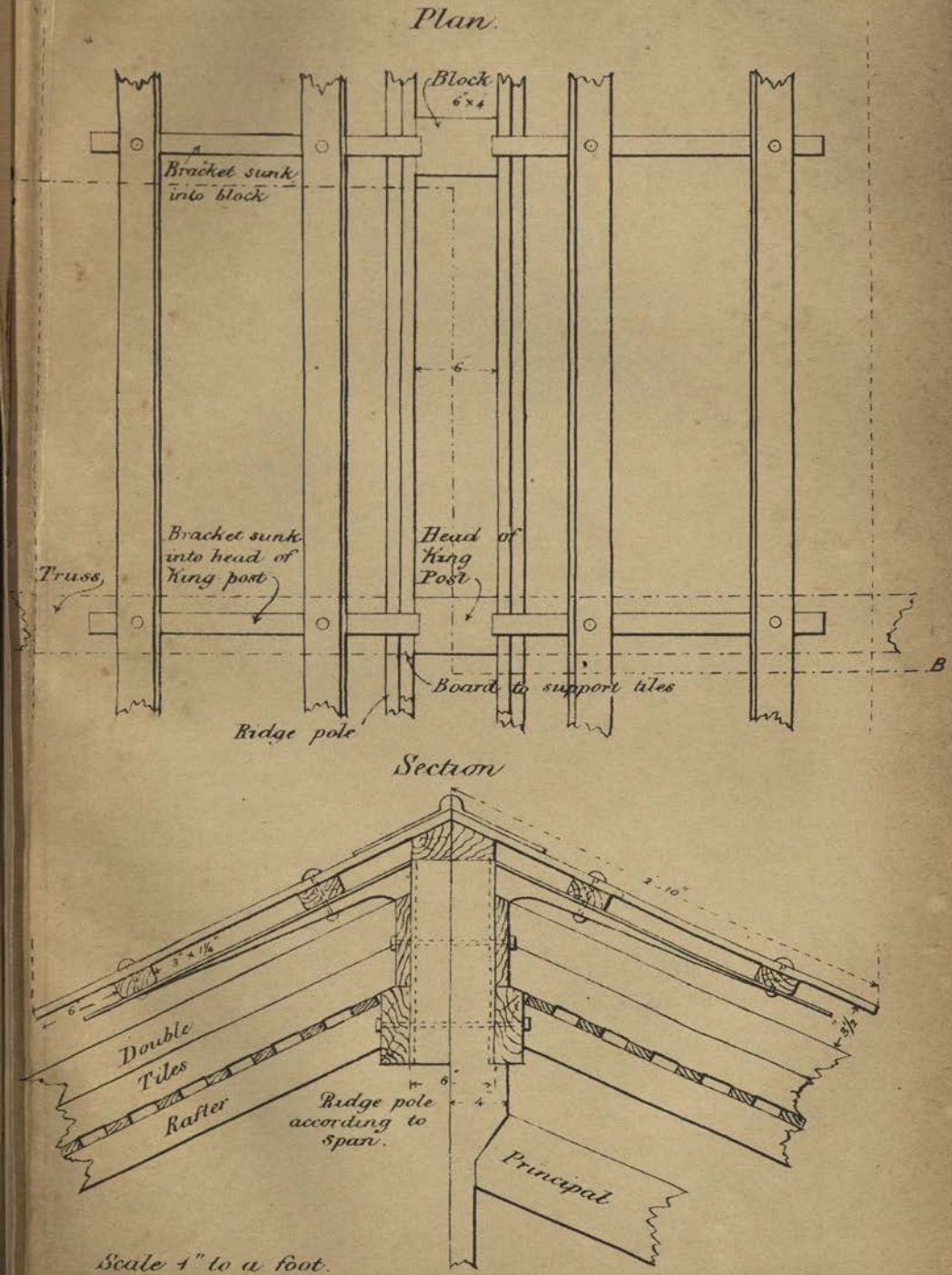
6. When the roofing is of tiles a pair of boards must be provided and secured on either side of the head of the king posts against which the ends of the tiles will abut.

Note.—This ventilator is especially adapted for tiled roofs, and has been largely used on the barracks at Poona, Kirkee, Ahmedabad, Ahmednagar, Belgaum, and Deoláli. It can be adapted for either king or queen posts trusses. Its cost in Bombay is Rs. 4-2-0 per lineal foot, including cast iron brackets, corrugated sheets, ridge capping, and all bolts and nuts.

Ridge Ventilator.

(Howard's Pattern.)

Plate XVII.

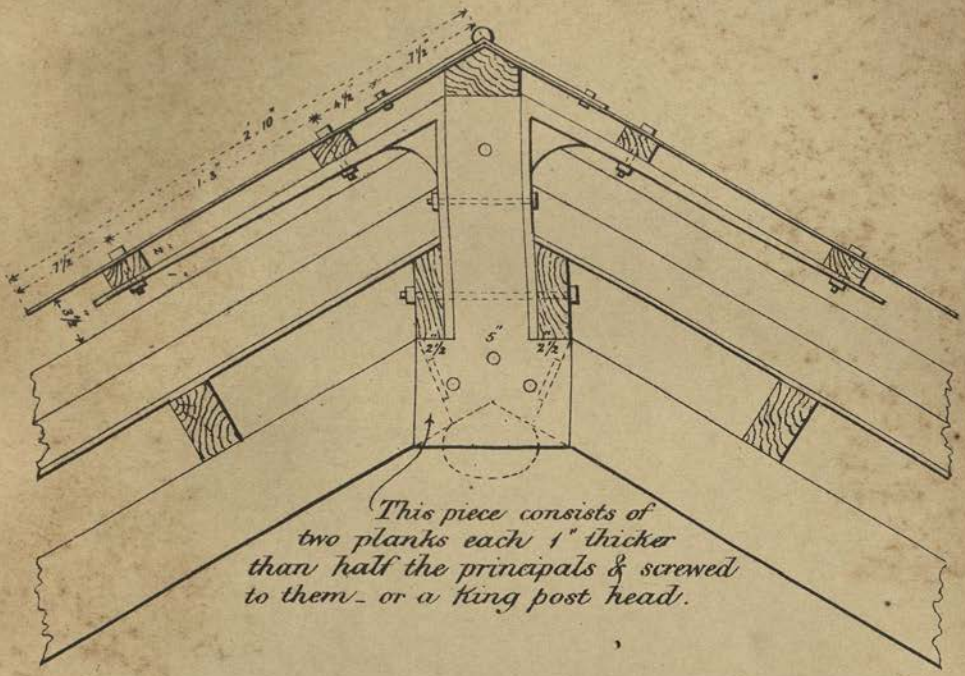


Govt Photozinco Office Poona 1887

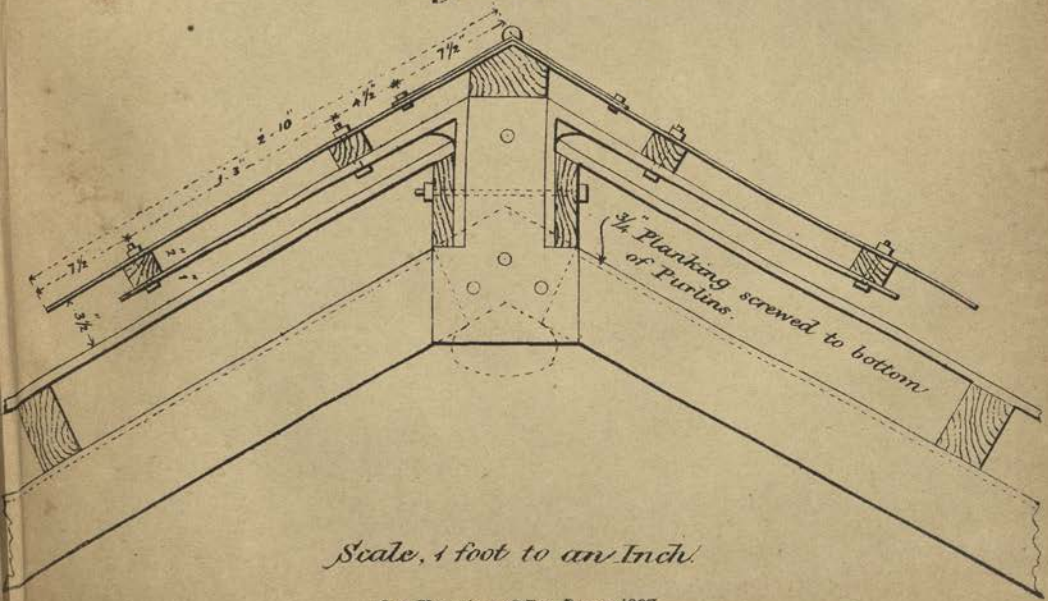
Howard's Ventilator.

Adapted for purlin roof queen post truss.

Double Tiles.



Corrugated Iron.



Scale, 1 foot to an Inch.

Govt Photozinco. Office, Poona, 1887.

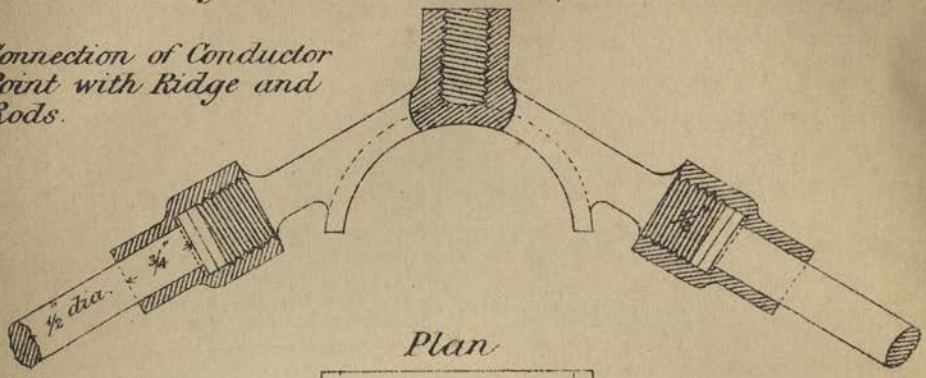
Lightning Conductors.

Plate XVIII.

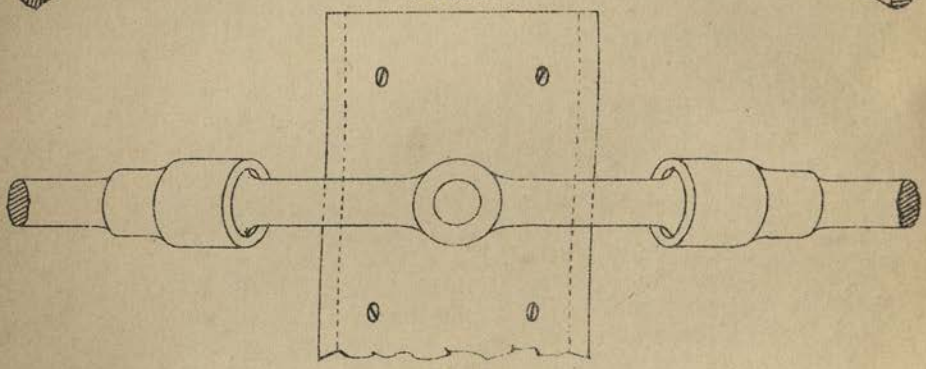
Scale, = Half Size.

Ridge connections for Copper Conductors

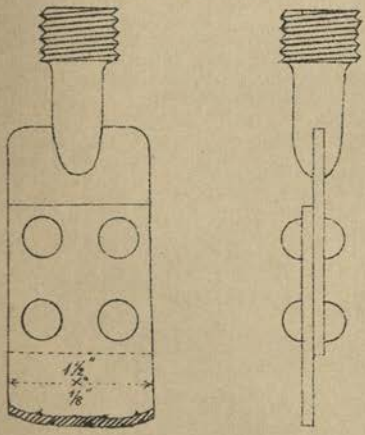
Connection of Conductor Point with Ridge and Rods.



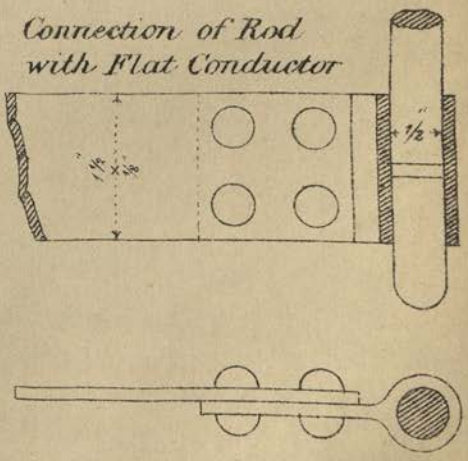
Plan



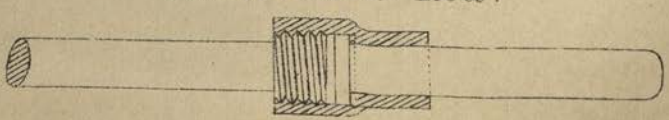
Connection of Flat with Rod Conductor.



Connection of Rod with Flat Conductor



Connections for Rod.



CLIX.—Lightning Conductors.

1. To be copper rod (or rope) $\frac{1}{2}''$ diameter, copper tape $1\frac{1}{2}'' \times \frac{1}{8}''$, or round iron rod 1″ diameter.

Materials.

2. The upper end of the conductor under all circumstances to be a solid copper rod $\frac{3}{4}''$ diameter terminated in a cone of which the height is equal to the radius of its base. To project at least 5 feet into the air above one or more of the highest points of the building to which it is applied.

Upper terminate or points.

Note.—It is desirable that the points be platinized, gilded or nickel-plated so as to resist oxidation.

3. The conductors to be attached to the building by proper hold-fasts, to be perfectly continuous from top to bottom, and preferentially to be taken down the side of the building most exposed to rain. All metal surfaces in ridges, roofs, gutters, &c., to be connected by plates of copper with the conducting system.

Conductor.

4. All joints in copper rods besides being well cleaned, screwed, scarfed, or riveted to be soldered in addition.

Joints.

5. The lower extremity of the conductor to be carried about 3 feet into the ground. A copper tape $1\frac{1}{2}'' \times \frac{1}{8}''$ to be then soldered to it, and carried along a trench 30 to 40 feet in length (of about the same depth) and connected with a copper plate not less than 9 square feet in area and $\frac{1}{16}$ inch thick buried in permanently wet earth and surrounded with charcoal. The copper tape to be laid in charcoal, and the trench filled up with sand.

Earth connection.

6. The surface drainage in the vicinity to be regulated, if possible, to flow over the site of the trench.

Surface drainage.

Note.—The copper used should not weigh less than 6 oz. per foot run, or its conductivity be less than 90 per cent. of that of pure copper. Iron may be used, but should weigh not less than $2\frac{1}{4}$ lbs. per foot run. If copper rope be used, no individual wire should be less than 12 B. W. G.—See also "Code of Rules for the Erection of Lightning Conductors."

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATIONS.

CVIII.—Double-tiled Roof Covering.

DOUBLE TILING ONLY.

Artificers, Labourers, and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Battens ...R. ft.	300	1 8 100 R.F.	4 8			
Nails for battens and rafters ... lbs.	6	1 0 6 lbs.	1 0			
Tiles ... No.	2200	4 0 1,000	8 13			
Sundries	..	... ...	0 4			
		Total Materials.	14 9			
Labour.						
Tile-turners ...	2	0 8 each.	1 0			
Women	3	0 2 do.	0 6			
Carpenter	1	0 12 do.	0 12			
Cooly	1	0 4 do.	0 4			
Bhistie	¼	0 8 do.	0 2			
Sundries	...	... ...	0 3			
		Total Labour...	2 11			
Total for 100 Supl. Feet of double tiling and battens only...			17 4		Total for 100 Supl. Feet of double tiling and battens only.	

CIX.—Setting Hips and Ridges in Chunam.

Artificers, Labourers, and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Ridge Tiles... No.	150	4 0 100 No.	6 0			
Lime ... C. F.	8	12 0 40 C. F.	2 6			
Sand ... C. F.	12	2 0 100 C. F.	0 4			
Sundries	...	... ...	0 3			
		Total Materials.	8 13			
Labour.						
Bricklayers... ...	4	0 10 each.	2 8			
Coolies	2	0 3 do.	0 6			
Women	2	0 2 do.	0 4			
Bhistie	¼	0 8 do.	0 2			
Tile-turner	½	0 8 do.	0 4			
Woman	½	0 2 do.	0 1			
Grinding chunam. C. F.	12	3 0 100 C. F.	0 6			
Sundries	...	... ...	0 4			
		Total Labour...	4 3			
Total for 100 R. F. of setting ridges and hips in chunam			13 0	Total for 100 R. F. of setting ridges and hips in chunam ...		

CX.—Setting double Eaves in Chunam.

Artificers, Labourers, and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime ... ...C. F.	8	12 0 40 C.F.	2 6			
Sand ... ...C. F.	12	2 0 100 C.F.	0 4			
Sundries	...	... ...	0 3			
		Total Materials.	2 13			
Labour.						
Bricklayers ...	3	0 10 each.	1 14			
Coolies	1	0 3 do.	0 3			
Women	3	0 2 do.	0 6			
Bhistie	¼	0 8 do.	0 2			
Grinding chunam ...	12	3 0 100 C.F.	0 6			
Sundries	...	... ...	0 4			
		Total Labour...	3 3			
Total for 100 R. F. of setting double eaves in chunam			6 0	Total for 100 R. F. of setting double eaves in chunam ...		

CXI.—Eaves Board.

Artificers, Labourers, and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teak plank 6″ × ½″ R.F.	100	0 1 foot	6 4			
Screws 1½″ ...Dozen.	4	0 1 dozen	0 4			
Sundries	...	... ...	0 1			
		Total Materials.	6 9			
Labour.						
Carpenters	2	0 12 each	1 8			
Coolies	2	0 3 do.	0 6			
Sundries	...	... ...	0 1			
		Total Labour...	1 15			
Total for 100 R.F. of eaves board...			8 8	Total for 100 R.F. of eaves board ...		

CXII.—Double Tiled Roofing, xii feet Span. (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak)...C.F.	16·67	3 0 C.F.	50 0			
Teak battens 2″ × ½″...R.F.	653	1 8 100 R.F.	9 13			
Iron-work in trusses, &c. ... ... lbs.	16	0 3 lbs.	3 0			
Nails ... ... lbs.	8	0 2 lbs.	1 0			
Sundries	...	... ...	0 12			
		Total Materials.	64 9			
Labour.						
On framed timber ...C.F.	3·46	0 12 C.F.	2 9			
On wrought timber...C.F.	13·21	0 6 C.F.	4 15			
On fitting iron-work ...	...	... ...	1 0			
On fixing battens ...R.F.	623	0 6 100 R.F.	2 5			
Carriage of timber...C.F.	21	0 4 C.F.	5 4			
Sundries	...	... ...	0 12			
		Total Labour...	16 13			
Add.						
Double tiling ... S.F.	208	10 8 100 S.F.	21 13			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 do.	3 0			
Total for 208 S.F. Roofing completed...			108 11			
Or for 100 S.F. Roofing completed...			52 4			

Construction.—Trusses 10 feet apart, purlins $4\frac{3}{4}'' \times 6\frac{3}{4}''$, common rafters $1\frac{3}{4}'' \times 2\frac{3}{4}''$, at 18″ inches, ridge pole $2\frac{1}{4}'' \times 7\frac{1}{2}''$, wall plate $4'' \times 3\frac{1}{2}''$, battens $2'' \times \frac{1}{2}''$, double tiles, hips, ridges, and eaves set in chunam.

CXIII.—Double Tiled Roofing, xiv feet Span (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) ...C.F.	20·08	3 0 C.F.	60 4			
Teak battens 2″ × ½″...R.F.	722	1 8 100 R.F.	10 13			
Iron-work in trusses, &c. ... ... lbs.	19	0 3 lbs.	3 9			
Nails ... ... lbs.	10	0 2 lbs.	1 4			
Sundries	...	... ...	0 12			
		Total Materials.	76 10			
Labour.						
On framed timber ...C.F.	4·30	0 12 C.F.	3 4			
On wrought timber...C.F.	15·78	0 6 C.F.	5 15			
On fitting iron-works ...	...	... ...	1 2			
On fixing battens ...R.F.	689	0 6 100 R.F.	2 9			
Carriage of timber... C.F.	25	0 4 C.F.	0 4			
Sundries	...	... ...	0 12			
		Total Labour...	19 14			
Add.						
Double tiling ...S.F.	230	10 8 100 S.F.	24 2			
Setting ridges and hips ... ...R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 do.	3 0			
Total for 230 S.F. Roofing completed...			126 2			
Or for 100 S.F. Roofing completed...			54 13			

Construction.—Trusses 10 feet apart, purlins 5″ × 7″, common rafters 2″ × 3″, at 18″ inches, ridge pole 2½″ × 7¾″, wall plate 4″ × 3½″, battens 2″ × ½″, double tiles, hips, ridges, and eaves set in chunam.

CXIV.—Double Tiled Roofing, xvi feet Span. (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) C.F.	24·03	3 0 C.F.	72 1			
Teak battens 2″ × ½″ R.F.	797	1 8 100 R.F.	11 15			
Iron-work in trusses, &c. ... ... lbs.	23	0 3 lbs.	4 5			
Nails ... ... lbs.	12	0 2 lbs.	1 8			
Sundries	...	... ...	1 0			
		Total Materials.	90 13			
Labour.						
On framed timber ...C.F.	5·39	0 12 C.F.	4 1			
On wrought timber...C.F.	18·64	0 6 C.F.	7 0			
On fitting iron-work ...	...	... ...	1 4			
On fixing battens R.F.	761	0 6 100 R.F.	2 14			
Carriage of timber...C.F.	30	0 4 C.F.	7 8			
Sundries	...	... ...	1 0			
		Total Labour ...	23 11			
Add.						
Double tiling ... S.F.	254	10 8 100 S.F.	26 11			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 do.	3 0			
Total for 254 S.F. Roofing completed...			146 11			
Or for 100 S.F. Roofing completed...			57 12			

Construction.—Trusses 10 feet apart, purlins 5″×7¼″, common rafters 2¼″×3¼″, at 18″ inches, ridge pole 2½″×8″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXV.—Double Tiled Roofing, xviii feet Span. (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) C.F.	29·06	3 0 C.F.	87 3			
Teak battens 2″ × ½″ R.F.	870	1 8 100 R.F.	13 1			
Iron-work in trusses, &c. ... ... lbs.	27	0 3 lbs.	5 1			
Nails ... ... lbs.	14	0 2 lbs.	1 12			
Sundries	...	... ...	1 2			
		Total Materials.	108 3			
Labour.						
On framed timber ...C.F.	6·93	0 12 C.F.	5 3			
On wrought timber..C.F.	22·13	0 6 C.F.	8 5			
On fitting iron-work ...	...	... ...	1 8			
On fixing battens ...R.F.	830	0 6 100 R.F.	3 2			
Carriage of timber...C.F.	35	0 4 C.F.	8, 12			
Sundries	...	... ...	1 2			
		Total Labour ...	28 0			
Add.						
Double tiling ... S.F.	277	10 8 100 S.F.	29 1			
Setting ridges and hips ... ...R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 do.	3 0			
Total for 277 S. F. Roofing completed...			170 12			
Or for 100 S.F. Roofing completed...			61 10			

Construction.—Trusses 10 feet apart, purlins 5¼″×7¼″, common rafters 2½″×3½″, at 18″ inches, ridge pole 2½″×8½″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXVI.—Double Tiled Roofing, xx feet Span. (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) C.F.	32·90	3 0 C.F.	98 11			
Teak battens 2″ × ½″ R.F.	942	1 8 100 R.F.	14 2			
Iron-work in trusses, &c. ... ... lbs.	32	0 3 lbs.	6 0			
Nails ... ... lbs.	16	0 2 lbs.	2 0			
Sundries	...	... ...	1 4			
		Total Materials.	122 1			
Labour.						
On framed timber ... C.F.	8·37	0 12 C.F.	6 4			
On wrought timber... C.F.	24·53	0 6 C.F.	9 3			
On fitting iron-work ...	...	... ...	1 12			
On fixing battens ... R.F.	899	0 6 100 R.F.	3 6			
Carriage of timber... C.F.	39	0 4 C.F.	9 12			
Sundries	...	... ...	1 4			
		Total Labour...	31 9			
Add.						
Double tiling ... S.F.	300	10 8 100 S.F.	31 8			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves. R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ⅝″ R.F.	20	15 0 do.	3 0			
Total for 300 S.F. Roofing completed...			190 10			
Or for 100 S.F. Roofing completed...			63 9			

Construction.—Trusses 10 feet apart, purlins 5¼″×7½″, common rafters 2½″×3¾″, at 18″ inches, ridge pole 2½″×8¾″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXVII.—Double Tiled Roofing xxii feet Span. (Kingpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) ... C.F.	39·56	3 0 C.F.	118 11			
Teak battens 2″×½″ R.F.	1013	1 8 100 R.F.	15 3			
Iron-work in trusses, &c. ... ... lbs.	37	0 3 lbs.	6 15			
Nails ... ... lbs.	19	0 2 lbs.	2 6			
Sundries	...	... ...	1 4			
		Total Materials.	144 7			
Labour.						
On framed timber ... C.F.	10·30	0 12 C.F.	7 12			
On wrought timber C.F.	29·26	0 6 C.F.	11 0			
On fitting iron-work ...	...	... ...	2 0			
On fitting battens ... R.F.	967	0 6 100 R.F.	3 10			
Carriage of timber ... C.F.	47	0 4 C.F.	11 12			
Sundries	...	... ...	1 4			
		Total Labour...	37 6			
Add.						
Double tiling ... S.F.	323	10 8 100 S.F.	33 15			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves, R.F.	20	6 0 do.	1 3			
Eaves board 8″×¾″ R.F.	20	15 0 do.	3 0			
Total for 323 S.F. Roofing completed ...			221 4			
Or for 100 S.F. Roofing completed ...			68 8			

Construction.—Trusses 10 feet apart, purlins 5½″×7¾″, common rafters 2¾″×4″, at 18″ inches, ridge pole 2½″×9½″, wall plate, 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXVIII.—Double Tiled Roofing, xxiv feet Span. (Queenpost).

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) ...C.F.	38·98	3 0 C.F.	116 15			
Teak battens 2″×½″ R.F.	1086	1 8 100 R.F.	16 5			
Iron-work in trusses, &c. ... ... lbs.	37	0 3 lbs.	6 15			
Nails ... ... lbs.	19	0 2 lbs.	2 6			
Sundries	...	... ...	1 8			
		Total Materials.	144 1			
Labour.						
On framed timber... C.F.	11·83	0 12 C.F.	8 14			
On wrought timber. C.F.	27·15	0 6 C.F.	10 3			
On fitting iron-work ...	...	... ...	2 4			
On fixing battens . R.F.	1036	0 6 100 R.F.	3 14			
Carriage of timber . C.F.	47	0 4 C.F.	11 12			
Sundries	...	... ...	1 8			
		Total Labour...	38 7			
Add.						
Double tiling ... S.F.	346	10 8 100 S.F.	36 5			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″×¾″...R.F.	20	15 0 do.	3 0			
Total for 346 S.F. Roofing completed ...			224 5			
Or for 100 S.F. Roofing completed ...			64 13			

Construction.—Trusses 10 feet apart, purlins 5″×7″, common rafters 2¼″×3″, at 18″ inches, ridge pole 2½″×7⅜″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXIX.—Double Tiled Roofing, xxvi feet Span. (Queenpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) ... C.F.	42·71	3 0 C.F.	128 2			
Teak battens 2″ × ½″ R.F.	1158	1 8 100 R.F.	17 6			
Iron-work in trusses, &c. ... ... lbs.	43	0 3 lbs.	8 1			
Nails ... ... lbs.	22	0 2 lbs.	2 12			
Sundries	...	... ...	1 8			
		Total Materials.	157 13			
Labour.						
On framed timber . C.F.	13·04	0 12 C.F.	9 12			
On wrought timber. C.F.	29·67	0 6 C.F.	11 2			
On fitting iron-work ...	..	... ...	2 8			
On fixing battens... R.F.	1105	0 6 100 R.F.	4 2			
Carriage of timber . C.F.	51	0 4 C.F.	12 12			
Sundries	...	... ...	1 8			
		Total Labour...	41 12			
Add.						
Double tiling ... S.F.	369	10 8 100 S.F.	38 12			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves. R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ ... R.F.	20	15 0 do.	3 0			
Total for 369 S.F. Roofing completed ...			243 13			
Or for 100 S.F. Roofing completed ...			66 1			

Construction.—Trusses 10 feet apart, purlins 5″ × 7¼″, common rafters 2¼″ × 3¼″, at 18″ inches, ridge pole 2½″×8″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXX.—Double Tiled Roofing, xxviii feet Span. (Queenpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak) C. F.	50·19	3 0 C. F.	150 9			
Teak battens 2″ × ½″ R.F.	1234	1 8 100 R. F.	18 8			
Iron-work in trusses, &c. ... ... lbs.	47	0 3 lbs.	8 13			
Nails ... ... lbs.	24	0 2 lbs.	3 0			
Sundries	...	... ...	2 0			
		Total Materials.	182 14			
Labour.						
On framed timber C.F.	15·37	0 12 C. F.	11 8			
On wrought timber C.F.	34·82	0 6 C. F.	13 1			
On fitting iron-work ...	...	... ...	2 12			
On fixing battens R.F.	1177	0 6 100 R. F.	4 7			
Carriage of timber C.F.	59	0 4 C. F.	14 12			
Sundries	...	... ...	2 0			
		Total Labour...	48 8			
Add.						
Double tiling ... S. F.	393	10 8 100 S. F.	41 4			
Setting ridges and hips... ... R. F.	10	13 0 100 R. F.	1 5			
Setting double eaves R. F.	20	6 0 do.	1 3			
Eaves board 8″ × ⅝″ R.F.	20	15 0 do.	3 0			
Total for 393 S. F. Roofing completed ...			278 2			
Or for 100 S. F. Roofing completed ...			70 12			

Construction.—Trusses 10 feet apart, purlins 5½″ × 7½″, common rafters 2½″×3½″, at 18″ inches, ridge pole 2½″×8½″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges, and eaves set in chunam.

CXXI.—Double Tiled Roofing, xxx feet Span. (Queenpost.)

(Ordinary Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) C.F.	55·34	3 0 C.F.	166 0			
Teak battens 2″ × ½″ R.F.	1306	1 8 100 R.F.	19 9			
Iron-work in trusses, &c. ... ... lbs.	54	0 3 lbs.	10 2			
Nails .. ... lbs.	27	0 2 lbs.	3 6			
Sundries	...	... ...	2 0			
		Total Materials .	201 1			
Labour.						
On framed timber C.F.	17·66	0 12 C.F.	13 4			
On wrought timber C.F.	37·68	0 6 C.F.	14 2			
On fitting iron-work ...	...	... ...	3 0			
On fixing battens R.F.	1246	0 6 100 R.F.	4 11			
Carriage of timber C.F.	64	0 4 C.F.	16 0			
Sundries	...	... ...	2 0			
		Total Labour...	53 1			
Add.						
Double tiling ... S.F.	416	10 8 100 S.F.	43 11			
Setting ridges and hips ... ... R.F.	10	13 0 100 R.F.	1 5			
Setting double eaves R.F.	20	6 0 do.	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 do.	3 0			
Total for 416 S. F. Roofing completed ...			303 5			
Or for 100 S. F. Roofing completed ...			72 15			

Construction.—Trusses 10 feet apart, purlins 5½″×7½″, common rafters 2½″×3¾″, at 18″ inches, ridge pole 2½″×8¾″, wall plate 4″×3½″, battens 2″×½″, double tiles, hips, ridges and eaves set in chunam.

CXXII.—Double Tiled Verandah Roofing, vi feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak) C.F.	7·94	3 0 C.F.	23 13			
Teak battens 2″ × ½″ R.F.	272	1 8 100 R.F.	4 1			
Nails ... ... lbs.	4	0 2 lbs.	0 8			
Sundries	...	... ...	0 6			
		Total Materials.	28 12			
Labour.						
On wrought timber C.F.	7·94	0 6 C.F.	3 0			
On fixing battens R.F.	259	0 6 100 R.F.	1 0			
Carriage of timber C.F.	10	0 4 C.F.	2 8			
Sundries	...	... ...	0 6			
		Total Labour...	6 14			
Add.						
Double tiling ... S.F.	87	10 8 100 S.F.	9 2			
Setting double eaves R.F.	10	6 0 100 R.F.	0 10			
Eaves board 8″ × ¾″ R.F.	10	15 0 do.	1 8			
Total for 87 S. F. Roofing completed...			46 14			
Or for 100 S. F. Roofing completed...			53 14			

Construction—Post plate 4″×7″, common rafters 2½″×3¾″, at 18″ inches, wall plate 3½ ×4″, battens 2″×½″, double tiles, and eaves set in chunam.

CXXIII.—Double Tiled Verandah Roofing, viii feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak) C. F.	10·63	3 0 C.F.	31 14			
Teak battens 2″ × ½″ R.F.	345	1 8 100 R.F.	5 3			
Nails ... ... lbs.	7	0 2 lbs.	0 14			
Sundries	...	... ...	0 8			
		Total Materials.	38 7			
Labour.						
On wrought timber C.F.	10·63	0 6 C.F.	4 0			
On fixing battens R.F.	329	0 6 100 R.F.	1 4			
Carriage of timber C.F.	13	0 4 C.F.	3 4			
Sundries	...	... ...	0 8			
		Total Labour...	9 0			
Add.						
Double tiling ... S.F.	110	10 8 100 S.F.	11 9			
Setting double eaves R.F.	10	6 0 100 R.F.	0 10			
Eaves board 8″ × ¾″ R.F.	10	15 0 do.	1 8			
Total for 110 S. F. Roofing completed...			61 2			
Or for 100 S. F. Roofing completed...			55 9			

Construction.—Principals 3½″×7½″, at 10 feet apart, post plate 4½″×6¾″, purlins 4½″×7″, common rafters 1¾″×2¾″, at 18″ inches, wall plate 3½ ″4″, battens 2″×½″, double tiles and eaves set in chunam.

CXXIV.—Double Tiled Verandah Roofing, x feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak) C.F.	14·61	3 0 C.F.	43 13			
Teak battens 2″ × ½″ R.F.	418	1 8 100 R.F.	6 4			
Nails ... ... lbs.	8	0 2 lbs.	1 0			
Sundries	...	... ...	0 8			
		Total Materials.	51 9			
Labour.						
On wrought timber C.F.	14·61	0 6 C.F.	5 7			
On fixing battens R.F.	398	0 6 100 R.F.	1 8			
Carriage of timber C.F.	18	0 4 C.F.	4 8			
Sundries	...	... ...	0 8			
		Total Labour...	11 15			
Add.						
Double tiling ... S.F.	132	10 8 100 S.F.	13 14			
Setting double eaves R.F.	10	6 0 100 R.F.	0 10			
Eaves board 8″ × ⅜″ R.F.	10	15 0 do.	1 8			
Total for 132 S.F. Roofing completed ...			79 8			
Or for 100 S. F. Roofing completed ...			60 4			

Construction.—Principals 3¾″×9″ at 10 feet apart, post plate 4½″×7″, purlins 4½″×7½″, common rafters 2¼″×3¼″, at 18″ inches, wall plate 3½″×4″, battens 2″×½″, double tiles and eaves set in chunam.

CXXV.—Double Tiled Roofing, xii feet Span (Kingpost).

(Purlin Rafter Construction).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak) C.F.	15·18	3 0 C.F.	45 9			
Iron-work in trusses, &c. ... ... lbs.	14	0 3 lbs.	2 10			
Nails ... ... lbs.	7	0 2 lbs.	0 14			
Teak planking 6″ × ¾″, S.F.	229	17 0 100	38 15			
Screws, 1¼″ ...dozen	23	0 2 dozen	2 14			
Sundries	...	... ...	0 12			
		Total Materials.	91 10			
Labour.						
On framed timber C.F.	3·46	0 12 C.F.	2 9			
On wrought timber C.F.	11·72	0 6 C.F.	4 6			
On fitting iron-work ...	...	... ...	1 0			
On laying planking S.F.	208	2 4 100	4 11			
Carriage of timber C.F.	29	0 4 C.F.	7 4			
Sundries	...	... ...	0 12			
		Total Labour...	20 10			
Add.						
Double tiling ... S.F.	208	10 8 100	21 13			
Setting ridges and hips... ... R.F.	10	13 0 100	1 5			
Setting double eaves R.F.	20	6 0 100	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 100	3 0			
Total for 208 S.F. Roofing completed ...			139 9			
Or for 100 S.F. Roofing completed ...			67 2			

Construction.—Trusses 10 feet apart, purlin rafters 3½″ × 5¼″ at 3 feet apart, ridge pole 3″ × 7¼″, wall plate 4″×3½″, planking ¾″, tongued and grooved, double tiles, hips, ridges and eaves set in chunam.

CXXVI.– Double Tiled Roofing, xiv feet Span (Kingpost).

(Purlin Rafter Construction).

Materials and Labour.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Timber in scantling in Bombay (Teak) C.F.	16·02	3	0	C.F.	48	1						
Iron-work in trusses, &c. ... ... lbs.	17	0	3	lbs.	3	3						
Nails ... ... lbs.	9	0	2	lbs.	1	2						
Teak planking 6″ × ¾″ S.F.	253	17	0	100	43	0						
Screws 1¼″ ... doz.	25	0	2	doz.	3	2						
Sundries	...	...		...	0	12						
		Total Materials.			99	4						
Labour.												
On framed timber C.F.	4·30	0	12	C.F.	3	4						
On wrought timber C.F.	11·72	0	6	C.F.	4	6						
On fitting iron-work ...	...	...		...	1	2						
On laying planking S.F.	230	2	4	100	5	3						
Carriage of timber C.F.	32	0	4	C.F.	8	0						
Sundries	...	...		...	0	12						
		Total Labour ...			22	11						
Add.												
Double tiling... S.F.	230	10	8	100	24	2						
Setting ridges and hips... ... R.F.	10	13	0	100	1	5						
Setting double eaves ... R.F.	20	6	0	100	1	3						
Eaves board 8″ × ¾″ R.F.	20	15	0	100	3	0						
Total for 230 S.F. Roofing completed...					151	9						
Or for 100 S.F. Roofing completed ...					65	14						

Construction.—Trusses 10 feet apart, purlin rafters 3½″×5¼″ at 3 feet apart, ridge pole 3″×7¼″, wall plate 4″×3½″, planking ¾″ tongued and grooved, double tiles, hips, ridges and eaves set in chunam.

CXXVII.—Double Tiled Roofing, xvi feet Span (Kingpost).

(Purlin Rafter Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak) C.F.	17·11	3 0 C.F.	51 5			
Iron-work in trusses, &c. ... ... lbs.	19	0 3 lbs.	3 9			
Nails ... ... lbs.	10	0 2 lbs.	1 4			
Teak planking 6″ × ¾″ S.F.	279	17 0 100	47 7			
Screws 1¼″ ... doz.	28	0 2 dozen	3 8			
Sundries	...	.....	1 0			
		Total Materials.	108 1			
Labour.						
On framed timber C.F.	5·39	0 12 C.F.	4 1			
On wrought timber ... C.F.	11·72	0 6 C.F.	4 6			
On fitting iron-work ...	...	... ...	1 4			
On laying planking S.F.	254	2 4 100	5 11			
Carriage of timber C.F.	35	0 4 C.F.	8 12			
Sundries	...	... ...	1 0			
		Total Labour...	25 2			
Add.						
Double tiling ... S.F.	254	10 8 100	26 11			
Setting ridges and hips ... R.F.	10	13 0 100	1 5			
Setting double eaves ... R.F.	20	6 0 100	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 100	3 0			
Total for 254 S. F. Roofing completed...			165 6			
Or for 100 S. F. Roofing completed...			69 1			

Construction.—Trusses 10 feet apart, purlin rafters 3½″×5¼″ at 3 feet apart, ridge pole 3″×7¼″, wall plate 4″×3½″, planking ¾″ tongued and grooved, double tiles, hips, ridges and eaves set in chunam.

CXXVIII.—Double Tiled Roofing, xviii feet Span (Kingpost).

(Purlin Rafter Construction.)

Materials and Labour.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	p.	Rs.	a.
Materials.												
Timber in scantling in Bombay (Teak)	C.F. 21·20	3	0	C.F.	63	10						
Iron-work in trusses, &c.	lbs. 23	0	3	lbs.	4	5						
Nails	lbs. 12	0	2	lbs.	1	8						
Teak planking 6″ × ¾″	S.F. 304	17	0	100	51	11						
Screws 1¼″ ...	doz. 30	0	2	doz.	3	12						
Sundries	...		.....		1	2						
		Total Materials.			126	0						
Labour.												
On framed timber	C.F. 6·93	0	12	C.F.	5	3						
On wrought timber	C.F. 14·27	0	6	C.F.	5	6						
On fitting iron-work ...	...		.....		1	8						
On laying planking	S.F. 277	2	4	100	6	4						
Carriage of timber.	C.F. 40	0	4	C.F.	10	0						
Sundries	...		.....		1	2						
		Total Labour ...			29	7						
Add.												
Double tiling ...	S.F. 277	10	8	100	29	1						
Setting ridges and hips	R.F. 10	13	0	100	1	5						
Setting double eaves	R.F. 20	6	0	100	1	3						
Eaves board 8″ × ¾″	R.F. 20	15	0	100	3	0						
Total for 277 S.F. Roofing completed ...					190	0						
Or for 100 S.F. Roofing completed...					68	9						

Construction.—Trusses 10 feet apart, purlin rafters 3½″×5¼″ at 3 feet apart, ridge pole 3″ ×7¼″, wall plate 4″×3½″, planking ¾″ tongued and grooved, double tiles, hips, ridges and eaves set in ch unam.

CXXIX.—Double Tiled Roofing, xx feet Span (King post)

(Purlin Rafter Construction.)

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Timber in scantling in Bombay (Teak). C.F.	22·64	3 0 C.F.	67 15			
Iron-work in trusses, &c. ... ...lbs.	27	0 3 lbs.	5 1			
Nails ... ...lbs.	14	0 2 lbs.	1 12			
Teak planking 6″ × ¾″ ... ...S.F.	330	17 0 100	56 2			
Screws 1¼″ dozen	33	0 2 doz.	4 2			
Sundries		.....	1 4			
		Total Materials.	136 4			
Labour.						
On framed timber. C.F.	8·37	0 12 C.F.	6 4			
On wrought timber C.F.	14·27	0 6 C.F.	5 6			
On fitting iron-work ...	...	.....	1 12			
On laying planking S.F.	300	2 4 100	6 12			
Carriage of timber C.F.	43	0 4 C.F.	10 12			
Sundries	...	.....	1 4			
		Total Labour ...	32 2			
Add.						
Double tiling ...S.F.	300	10 8 100	31 8			
Setting ridges and hips ... ...R.F.	10	13 0 100	1 5			
Setting double eaves ... ...R.F.	20	6 0 100	1 3			
Eaves board 8″ × ¾″ R.F.	20	15 0 100	3 0			
Total for 300 S.F. Roofing completed...			205 6			
Or for 100 S.F. Roofing completed...			68 7			

Construction.—Trusses 10 feet apart, purlin rafters 3½″×5¼″ at 3 feet apart, ridge pole 3″×7¼″ wall plate 4″×3½″, planking ¾″ tongued and grooved, double tiles, hips, ridges and eaves set in chunam.

CXXX—Double Tiled Roofing, xxii feet Span (Kingpost).

(Purlin Rafter Construction).

Materials and Labour.	No. or quantity.	Rate.			Amount.		No. or quantity.	Rate.			Amount.	
		Rs.	a.	Per	Rs	a.		Rs.	a.	Per	Rs.	a.
Materials.												
Timber in scantling in Bombay (Teak). C F.	27 12	3	0	C.F.	81	6						
Iron-work in trusses,&c. lbs.	30	0	3	lbs.	5	10						
Nails ... ... lbs.	15	0	2	lbs.	1	14						
Teak planking $6'' \times \frac{3}{4}''$ ... ...S.F.	355	17	0	100	60	6						
Screws $1\frac{1}{4}''$ ... dozen	36	0	2	dozen	4	8						
Sundries	...		.....		1	4						
		Total Materials.			155	0						
Labour.												
On framed timber.C.F.	10·30	0	12	C.F.	7	12						
On wrought timber C.F.	16·82	0	6	C.F.	6	5						
On fitting iron work ...	...		.....		2	0						
On laying planking S.F.	323	2	4	100	7	4						
Carriage of timber. C.F.	49	0	4	C.F.	12	4						
Sundries	...		.....		1	4						
		Total Labour ...			36	13						
Add.												
Double tiling ...S.F.	323	10	8	100	33	15						
Setting ridges and hips ... .. R F.	10	13	0	100	1	5						
Setting double eaves ... .. R.F.	20	6	0	100	1	3						
Eaves board $8'' \times \frac{3}{4}''$ R.F.	20	15	0	100	3	0						
Total for 323 S.F. Roofing completed...					231	4						
Or for 100 S.F. Roofing completed...					71	10						

Construction.—Trusses 10 feet apart, purlin rafters $3\frac{1}{2}'' \times 5\frac{1}{4}''$ at 3 feet apart, ridge pole $3'' \times 7\frac{1}{4}''$, wall plate $4'' \times 3\frac{1}{2}''$, planking $\frac{3}{4}''$, tongued and grooved, double tiles, hips, ridges and eaves set in chunam.

CXXXI.—Galvanized Corrugated Iron Roof Covering.

How to find out a rate for 2,100 S.F. of roofing. Find out the number and weight of sheets of the different sizes required. Say they are as follows :—

100 Sheets, 6′×2′ 3″ 20 gauge, weight=2,358 lbs.
100 do. 7′×2′ 3″ do. do. =2,821 lbs.

Total weight of galvanized iron sheet for 2,100 square feet | Total ...5,179 lbs. or 45·34 cwts.

Materials and Labour for 2,100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Galvanized Corrugated iron 20 B.W.G. in Bombay ... Cwt.	45·34	10 8 Cwt.	476 1			
Ridge Capping R.F.	84	0 9 R.F.	47 4			
Other materials, such as washers, screws, &c. (as hereafter shown) S.F.	2,100	2 0 100 S.F.	42 0			
		Total Materials.	565 5			
Labour.						
Carriage from Bombay ... ... Cwt.	45·34	2 8 Cwt.	113 6			
Rivetting and fixing (as hereafter shown) S.F.	2,100	4 0 100 S.F.	84 0			
Cutting sheets ... Cwt.	45·34	0 3 Cwt.	8 8			
Fixing ridge (as hereafter shown) R.F.	84	5 0 100 R.F.	4 3			
Sundries	...	.....	10 0			
		Total Labour...	220 1			
Total for 2,100 S. F. of Roof Covering...			785 6		Total for 2,100 S.F. of Roof Covering.	
Or for 100 S.F. of do.			37 5		Or for 100 S.F. of do	

CXXXII.—Rivetting and fixing Corrugated Iron Sheets.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Lead-washers lbs.	1	0 6 lbs.	0 6			
G. I. rivets do.	1½	0 4 do.	0 6			
G. I. screws do.	1	0 6 do.	0 6			
Iron for bolts, &c. do.	3	0 2 do.	0 6			
Charcoal ... do.	30	1 0 80 lbs.	0 6			
Sundries	...	.....	0 2			
		Total Materials.	2 0			
Labour for rivetting.						
Carpenter	1¾	0 12 each	1 5			
Coolies	1¾	0 3 do.	0 5			
Sundries	...	.....	0 1			
Labour for fixing, including fastening to purlins, &c., and making bolts.						
Carpenters	1½	0 12 each	1 2			
Coolies	1½	0 3 do.	0 5			
Smith	¾	0 12 do.	0 9			
Bellows-boy	¾	0 4 do.	0 3			
Sundries	...	.....	0 2			
		Total Labour...	4 0			
Total for rivetting and fixing 100 S. F. corrugated iron sheets ... „			6 0		Total for rivetting and fixing corrugated iron sheets.	

CXXXIII.—Fixing Galvanized Iron Ridge.

Artificers and Labourers for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Labour.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Carpenters	5	0 12 each.	3 12			
Coolies	5	0 3 do.	0 15			
Sundries	...	.....	0 5			
Total for fixing 100 R. feet of ridge ...			5 0		Total for fixing 100 R. feet of ridge ...	

Note.—Molesworth says $\frac{1}{10}$ weight to be added for lappage. This is not sufficient, and for accurate estimating a plan of each roof should be worked out, showing the exact number of sheets of each length required. The Table on the following page will give some idea of how the sheets can best be utilized for different spans, and percentage for lappage, the sheets being 2′ 3″ in width.

Weight of Galvanized Corrugated Iron.

No. 14 gauge weighs about 300 lbs. per 100 sq. ft.
16 „ „ „ 200 „
18 „ „ „ 236 „
20 „ „ „ 190 „
22 „ „ „ 150 „
24 „ „ „ 130 „

Corrugated Iron Roofing for various spans the sheets having a vertical and horizontal overlap of 6″ and their width being 2′ 3″.

Span.	Thickness of wall.	Horizontal Projection of Eaves.	Length of side.	No. and size of sheets in one side *x*.	Total percentage of sheet area over area of roof.	Remarks.
12	1·5	1·25	10·0	No. 1 of 7′ and ½ of 7′.	35 per cent.	The projection of eaves is reduced to suit the sheets
14	1·5	1·5	11·5	No. 1 of 8′ and ½ of 8′.	34	Do. do.
16	1·5	1·37	12·5	1 of 7′ and 1 of 6′...	33·71	Do. do.
18	1·5	1·25	13·5	2 of 7′	33	Do. do.
20	1·5	1·11	14·5	1 of 8′ and 1 of 7′...	33	Do. do.
		1·97	15·5	2 of 8′	32·71	Do. increased.
22	1·5	1·87	16·5	2 of 7′ and ½ of 7′...	36	Do. do.
24	1·5	1·67	17·5	1 of 8′, 1 of 7′ and ½ of 7′.	36	Do. do.
26	2·0	1·5	19·0	2 of 8′ and ½ of 8′...	36·34	
28	2·0	1·33	20·0	1 of 8′, 1 of 7, 1 of 6 or 3 of 7′.	35	Do. reduced.
30	2·0	1·20	21·0	1 of 8′ and 2 of 7′...	34·69	Do. do.
32	2·0	1·56	22·5	2 of 7′, 1 of 6′ and ½ of 8″.	37·15	Do. increased.
34	2·0	1·43	23·5	3 of 7′ and ½ of 8′ ...	36·78	Do. reduced.
36	2·0	1·23	24·5	1 of 8′, 2 of 7′ and ½ of 8″.	36·47	Do. do.
38	2·0	1·60	26	3 of 8′ and ½ of 7 ...	36	Do. increased.
40	2·0	1·96	27·5	1 of 8′ and 3 of 7′...	35·58	Do. do.

CXXXIV.—Corrugated Iron Roofing, xii feet Span (Kingpost).

Materials and Labour.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Timber in scantling in Bombay (Teak) C.F.	12·35	3	0	C.F.	37	1						
Iron-work in trusses ... ... lbs.	16	0	3	lb.	3	0						
Nails for purlins, &c. ... ... lbs.	8	0	2	lb.	1	0						
Teak planking 6″×½″ ... ... S.F.	154	14	0	100	21	9						
Screws 1¼″ ... doz.	15	0	2	doz.	1	14						
Galvanized Corrugated iron in Bombay 20 B.W.G. ...Cwt.	4¾	10	8	Cwt.	49	14						
Ridge Capping ...R.F.	10	0	9	R.F.	5	10						
Galvanized iron Guttering ... ...R.F.	20	0	14	R.F.	17	8						
Washers, rivets, screws, &c. ...S.F.	210	3	0	100	6	5						
Sundries			.....		1	8						
Labour.		Total Materials,			135	5						
On framed timber, C.F.	3·48	0	12	C.F.	2	10						
On wrought timber. C.F.	8·87	0	6	C.F.	3	5						
On fitting iron-work ...	...		.....		1	0						
On laying planking S.F.	140	2	4	100	3	2						
Rivetting and fixing sheets ... S.F.	210	4	0	100	8	6						
Cutting sheets ...Cwt.	4¾	0	3	Cwt.	0	14						
Fixing Ridge ...R.F.	10	5	0	100	0	8						
Fixing Gutters ... R.F.	20	3	6	100	0	11						
Carriage of iron sheets ... ...Cwt.	4¾	2	8	Cwt.	11	14						
Carraige of timber ... ...C.F.	19	0	4	C.F.	4	12						
Sundries			.....		0	8						
Add.		Total Labour...			37	10						
Galvanized iron wire netting ... ...S.F.	10	35	4	100	3	8						
Total for 210 S.F. Roofing completed ...					176	7						
Or for 100 S.F. Roofing completed ...					84	0						

Construction.—Trusses 10 feet apart, purlins 3½″×5¼″ at 3 feet apart, teak planking ½″ screwed to underside of purlins, ridge pole 2½″×7″, wall plate 4″×3½″, covering of Galvanized Corrugated iron 20 B.W.G., wire netting ¾″ Mesh under ridge pole.

CXXXV.—Corrugated Iron Roofing, xiv feet Span (Kingpost).

Materials and Labour.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.		Amount
		Rs.	a.	Per	Rs.	a.		Rs.	a. Per	Rs. a.
Materials.										
Timber in scantling in Bombay (Teak), C.F.	15·62	3	0	C.F.	46	14				
Iron-work in trusses ... ... lbs.	20	0	3	lb.	3	12				
Nails for purlins, &c. do.	10	0	2	lb.	1	4				
Teak planking 6″ × ½″ ... ... S.F.	182	14	0	·100	25	8				
Screws 1¼″ ... doz.	18	0	2	dozen.	2	4				
Galvanized Corrugated iron in Bombay 20 B. W. G. ...Cwt.	5¼	10	8	Cwt.	55	2				
Ridge Capping ...R.F.	10	0	9	R.F.	5	10				
Galvanized Iron Guttering ...R.F.	20	0	14	R.F.	17	8				
Washers, rivets, screws, &c. ... S.F	230	3	0	100	6	14				
Sundries	...		.....		1	12				
		Total Materials.			156	8				
Labour.										
On framed timber. C.F.	4·19	0	12	C.F.	3	2				
On wrought timber C.F.	11·43	0	6	C.F.	4	5				
On fitting iron-work ..	...		.....		1	4				
On laying planking S.F.	165	2	4	100	3	11				
Rivetting and fixing sheets ... ...S.F.	230	4	0	100	9	3				
Cutting sheets ...Cwt.	5¼	0	3	Cwt.	1	0				
Fixing Ridge ...R.F.	10	5	0	100	0	8				
Fixing Gutters ...R.F.	20	3	6	100	0	11				
Carriage of iron sheets ... ...Cwt.	5¼	2	8	Cwt.	13	2				
Carriage of timber C.F.	23	0	4	C.F.	5	12				
Sundries	...		.....		0	8				
Add.		Total Labour...			43	2				
Galvanized iron wire netting ... ...SF	10	35	4	100	3	8				
Total for 230 S.F. Roofing completed ...					203	2				
Or for 100 S.F. Roofing completed ...					88	5				

Construction.—Trusses 10 feet apart, purlins 3½″×5½″ at 3 feet apart, teak planking ½″ screwed to under side of purlins, ridge pole 2½″×7″, wall plate 4″×3½″, covering of Galvanized Corrugated iron 20 B. W. G., wire netting ¾″ Mesh under ridge pole.

CXXXVI.—Corrugated Iron Roofing, xvi feet Span (Kingpost).

Materials and Labour.	No of quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Timber in scantling in Bombay (Teak) .C.F.	16·6	3	0	C.F.	48	3						
Iron-work in trusses ... ... lbs.	22	0	3	lb,	4	2						
Nails for purlins, &c. lbs.	11	0	2	lb.	1	6						
Teak planking 6″× ½″ ... ...S.F.	204	14	0	100	28	9						
Screws 1¼″ ... doz.	20	0	2	doz.	2	8						
Galvanized Corrugated iron in Bombay 20 B. W. G. ...Cwt.	5¾	10	8	Cwt.	60	6						
Ridge Capping ...R.F.	10	0	9	R.F.	5	10						
Galvanized iron Guttering ...R.F.	20	0	14	R.F.	17	8						
Washers, rivets, screws, &c. ...S.F.	255	3	0	100	7	10						
Sundries...	...		.....		2	0						
		Total Materials.			177	14						
Labour.												
On framed timber. C.F.	5·17	0	12	C.F.	3	14						
On wrought timber.C.F.	11·43	0	6	C.F.	4	5						
On fitting iron-work ...	...		... ...		1	6						
On laying planking.S.F.	185	2	4	100	4	3						
Rivetting and fixing sheets ... ...S.F.	255	4	0	100	10	3						
Cutting sheets ...Cwt.	5¾	0	3	Cwt.	1	1						
Fixing ridge ...R.F.	10	5	0	100	0	8						
Fixing gutters ...R.F.	20	3	6	100	0	11						
Carriage of iron sheets ... ...Cwt.	5¾	2	8	Cwt.	14	6						
Carriage of timber,C.F.	25	0	4	C.F.	6	4						
Sunderies... ...	...		.....		0	8						
Add.		Total Labour...			47	5						
Galvanized iron wire netting... ...S.F.	10	35	4	100	3	8						
Total for 255 S.F, Roofing completed ...					228	11						
Or for 100 S.F. Roofing completed ...					89	11						

Construction.—Trusses 10 feet apart, purlins 3½″×5¼″ at 3 feet apart, teak planking ½″ screwed to underside of purlins, ridge pole 2½″×7″, wall plate 4″×3½″, covering of Galvanized Corrugated iron 20 B. W. G., wire netting ¾″ Mesh under ridge pole.

CXXXVII.—Corrugated Iron Roofing, xviii feet Span (Kingpost).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak). C.F.	17·69	3 0 C.F.	53 1			
Iron-work in trusses ... ... lbs.	23	0 3 lb.	4 5			
Nails for purlins &c. lbs.	11	0 2 lb.	1 6			
Teak planking 6″×½″ ... ...S.F.	237	14 0 100	33 3			
Screws, 1¼″ ...doz.	24	0 2 doz.	3 0			
Galvanized Corrugated iron in Bombay 20 B. W. G. ...Cwt.	6¼	10 8 Cwt.	65 10			
Ridge Capping ...R.F.	10	0 9 R.F.	5 10			
Galvanized iron Guttering ...R.F.	20	0 14 R.F.	17 8			
Washers, rivets, screws, &c. ...S.F.	275	3 0 100	8 4			
Sundries	...	.....	2 0			
Labour.		Total Materials.	193 15			
On framed timber, C.F.	6·26	0 12 C.F.	4 11			
On wrought timber, C.F.	11·43	0 6 C.F.	4 5			
On fitting iron-work...	...	.....	1 7			
On laying planking S.F.	215	2 4 100	4 13			
Rivetting and fixing sheets ... ...S.F.	275	4 0 100	11 0			
Cutting sheets .. Cwt.	6½	0 3 Cwt.	1 3			
Fixing Ridge ...R.F.	10	5 0 100	0 8			
Fixing Gutters ...R.F.	20	3 6 100	0 11			
Carriage of iron Sheets ... ...Cwt.	6¼	2 8 Cwt.	15 10			
Carriage of timber. C.F.	28	0 4 C.F.	7 0			
Sundries	...	.....	0 8			
Add.		Total Labour...	51 12			
Galvanized iron wire netting ... S.F.	10	35 4 100	3 8			
Total for 275 S. F. Roofing completed...			249 3			
Or for 100 S. F. Roofing completed...			90 10			

Construction.—Trusses 10 feet apart, purlins 3½″×5½″ at 3 feet apart, teak planking ½″ screwed to underside of purlins, ridge pole 2½×7″, wall plate 4″×3½″, covering of Galvanized Corrugated Iron 20 B. W. G., wire netting ⅜″ Mesh under ridge pole.

CXXXVIII.—Corrugated Iron Roofing, xx feet Span (Kingpost).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Timber in scantling in Bombay (Teak). C.F.	19·06	3 0 C.F.	57 3			
Iron-work in trusses ... ... lbs.	24	0 3 lb.	4 8			
Nails for purlins, &c. lbs.	12	0 2 lb.	1 8			
Teak planking $6'' \times \frac{1}{2}''$ ... ... S.F.	259	14 0 100	36 4			
Screws $1\frac{1}{4}''$ dozen.	26	0 2 doz.	3 4			
Galvanized Corrugated iron in Bombay 20 B. W. G. ... Cwt.	7	10 8 Cwt.	73 8			
Ridge Capping ... R.F.	10	0 9 R.F.	5 10			
Galvanized iron Guttering ...R.F.	20	0 14 R.F.	17 8			
Washers, rivets, screws, &c. ...S.F.	300	3 0 100	9 0			
Sundries	...	.....	2 4			
Labour.		Total Materials.	210 9			
On framed timber. C.F.	7·63	0 12 C.F.	5 12			
On wrought timber ... ... C.F.	11·43	0 6 C.F.	4 5			
On fitting iron-work ...	...	.....	1 8			
On laying planking S.F.	235	2 4 100	5 5			
Rivetting and fixing sheets ... ... S.F.	300	4 0 100	12 0			
Cutting sheets ... Cwt.	7	0 3 Cwt.	1 5			
Fixing Ridge ...R.F.	10	5 0 100	0 8			
Fixing Gutters ... R.F.	20	3 6 100	0 11			
Carriage of iron Sheets ... ...Cwt.	7	2 8 Cwt.	17 8			
Carriage of timber C.F.	30	0 4 C.F.	7 8			
Sundries	...	.....	0 12			
Add.		Total Labour ...	57 2			
Galvanized iron wire netting ... S.F.	10	35 4 100	3 8			
Total for 300 S. F. Roofing completed ...			271 3			
Or for 100 S.F. Roofing completed ...			90 6			

Construction.—Trusses 10 feet apart, purlins $3\frac{1}{2}'' \times 5\frac{1}{4}''$ at 3 feet apart., teak planking $\frac{1}{2}''$ screwed to underside of purlins, ridge pole $2\frac{1}{2}'' \times 7''$, wall plate $4'' \times 3\frac{1}{2}''$, covering of Galvanized Corrugated Iron 20 B. W. G., wire netting $\frac{3}{4}''$ Mesh under ridge pole.

CXXXIX.—Corrugated Iron Roofing, xxii feet Span (Kingpost).

Materials and Labour.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Timber in scantling in Bombay (Teak). C.F.	22·66	3	0	C.F.	68	0						
Iron-work in trusses ... ...lbs.	29	0	3	lb.	5	7						
Nails for purlins, &c.lbs.	15	0	2	lb.	1	14						
Teak planking 6″ × ½″ ... ...S.F.	292	14	0	100	40	14						
Screws 1¼″ ...doz.	29	0	2	doz.	3	10						
Corrugated iron in Bombay 20 B.W.G. ...Cwt.	7½	10	8	Cwt.	78	12						
Ridge Capping ...R.F.	10	0	9	R.F.	5	10						
Galvanized iron Guttering ...R.F.	20	0	14	R.F.	17	8						
Washers, rivets, screws, &c. ...S.F.	325	3	0	100	9	12						
Sundries	...		.....		2	8						
Labour.		Total Materials.			233	15						
On framed timber. C.F.	8·68	0	12	C.F.	6	8						
On wrought timber ... ...C.F.	13·98	0	6	C.F.	5	4						
On fitting iron-work ...	...		.....		1	13						
On laying planking.S.F.	265	2	4	100	5	15						
Rivetting and fixing sheets ... ...S.F.	325	4	0	100	13	0						
Cutting sheets ...Cwt.	7½	0	3	Cwt.	1	6						
Fixing Ridge ...R.F.	10	5	0	100	0	8						
Fixing Gutters ...R.F.	20	3	6	100	0	11						
Carriage of iron sheets ... ...Cwt.	7½	2	8	Cwt.	18	12						
Carriage of timber. C.F.	35	0	4	C.F.	8	12						
Sundries	...		.....		0	12						
Add.		Total Labour...			63	5						
Galvanized iron wire netting ...S.F.	10	35	4	100	3	8						
Total for 325 S.F. Roofing completed ...					300	12						
Or for 100 S.F. Roofing completed ...					92	8						

Construction.—Trusses 10 feet apart, purlins 3½″ × 5½″ at 3 feet apart, teak planking ½″ screwed to underside of purlins, ridge pole 2½″×7″, wall plate 4″×3½″, covering of Galvanized Corrugated Iron 20 B. W. G., wire netting ¾″ Mesh under ridge pole.

CXL.—Terraced Roofing, viii feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Teakwood in scantling ... ...C.F.	10¼	3 0 C.F.	30 12			
Flat tiles ... ... No.	480	15 0 1,000	7 3			
Lime ... ...C.F.	5	12 0 40 C.F.	1 8			
Sand ... ...C.F.	7½	2 0 100	0 2			
Sundries	...	.....	0 8			
		Total Materials.	40 1			
Labour.						
On wrought timber C.F.	10¼	0 6 C.F.	3 13			
Masons for setting tiles ... ... No.	3	0 10 each.	1 14			
Coolies ... ... No.	3	0 3 do.	0 9			
Bhisties ... ... No.	½	0 8 do.	0 4			
Grinding chunam. C.F.	7½	3 0 100	0 4			
White wash ...S.F.	200	0 8 do.	1 0			
Sundries	...	.....	0 4			
		Total Labour...	8 0			
Add.						
Concrete ... ...C.F.	20	20 0 100	4 0			
Total for 80 S.F. of Terraced Roofing ...			52 1			
Or for 100 S.F. of Terraced Roofing ...			65 1			

Note.—The cost of Terraced Roofing *exclusive of wood-work* would be Rs. 22 per 100 S.F.; its weight is assumed to be 75 lbs. per square foot, including wood-work.

Construction.—Joists 3″×4¼″ at 1 foot apart, supporting 2 layers of flat tiles 12″×6″×1″, covered with 3″ of fine concrete, and finished off with a surface layer of tiles also 12″×6″×1″.

Note.—Scantlings of Joists for the following spans:—
VI feet Span 3″×3¼″.
VIII do. do. 3″×4¼″.

CXLI.—Terraced Roofing, xii feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Teakwood in scantling ... ...C.F.	19½	3 0 C.F.	58 8			
Flat tiles ... ... No.	720	15 0 1,000	10 13			
Lime ... ...C.F.	8	12 0 40C.F.	2 6			
Sand ... ...C.F.	12	2 0 100	0 4			
Sundries	...	... ...	0 12			
Labour.		Total Materials.	72 11			
On wrought timber C.F.	19½	0 6 C.F.	7 5			
Masons for setting tiles ... ...No.	5	0 10 each.	3 2			
Coolies ... ...No.	5	0 3 do.	0 15			
Bhisties ... ...No.	½	0 8 do.	0 4			
Grinding chunam .C.F.	12	3 0 100	0 6			
White wash ...S.F.	300	0 8 do.	1 8			
Sundries	...	.....	0 6			
Add.		Total Labour...	13 14			
Concrete	30	20 0 100	6 0			
Total for 120 S. F. of Terraced Roofing ...			92 9			
Or for 100 S.F. of Terraced Roofing ...			77 2			

Note.—The cost of Terraced Roofing *exclusive of wood-work* would be Rs. 22 per 100 S.F; its weight is assumed to be 75 lbs. per square foot, including wood-work.

Construction.—Joists 3″×6¼″ at 1 foot apart, supporting 2 layers of flat tiles 12″×6″×1″, covered with 3″ of fine concrete and finished off with a surface layer of tiles also 12″×6″×1″.

Note.—Scantlings of Joists for the following spans :—

X feet Span 3″×5¼″.
XII do. do. 3″×6¼″.
XIV do. do. 3″×7¼″.

CXLII.—Terraced Roofing, xvi feet Span.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Teakwood in scantling ... ... C.F.	32	3 0 C.F.	96 0			
Flat tiles... ... No.	960	15 0 1,000	14 6			
Lime ... ... C.F.	10	12 0 40 C.F.	3 0			
Sand ... ... C.F.	15	2 0 100	0 5			
Sundries	...	.....	1 0			
Labour.		Total Materials.	114 11			
On wrought timber C.F.	32	0 6 C.F.	12 0			
Masons for setting tiles ... ... No.	6	0 10 each.	3 12			
Coolies ... ... No.	6	0 3 do.	1 2			
Bhisties ... ... No.	½	0 8 do.	0 4			
Grinding chunam C.F.	15	3 0 100	0 7			
White wash ...S.F.	400	0 8 do.	2 0			
Sundries	...	.....	0 8			
Add.		Total Labour...	20 1			
Concrete... ... C.F.	40	20 0 100	8 0			
Total for 160 S.F. of Terraced Roofing ...			142 12			
Or for 100 S.F. of Terraced Roofing ...			89 3			

Note.—The cost of Terraced Roofing *exclusive of wood-work* would be Rs. 22 per 100 S. F.; its weight is assumed to be 75 lbs. per square foot including wood-work.

Construction.—Joists 3″×8¼″ at 1 foot apart, supporting 2 layers of flat tiles 12″×6″×1″, covered with 3″ of fine concrete and finished off with a surface layer of tiles also 12″×6″×1″.

Note.—Scantlings of Joists for the following spans :—

XVI feet Span 3″ × 8¼″.
XVIII do. do. 3″×9¼″.
XX do. do. 3″×10¼″.

CXLIII.—Fire Proof Terraced Roofing.

Span in Feet.	Area supported.	Rolled Iron Beams 4 feet apart at Rs. 10 per cwt. including cost of Carriage, Painting and Fixing.							Cost of T Irons, concrete and Paving bricks laid complete at Rs. 44 as. 14 per 100 S. F.	Contingencies including bed plates, &c., at 5 per cent.	Total cost of area in column 2.	Rate per 100 S. F. Roofing complete.
		Length in feet.	Height of web.	Breadth of flange.	Thickness of web.	Weight in lbs. per R. F.	Total weight in lbs.	Cost.				
		′	″	″	″			Rs. a.	Rs. a.	Rs. a.	Rs. a.	Rs. a.
VI.	24	8	4	$1\frac{7}{8}$	$\frac{1}{4}$	8	64	5 11	10 12	0 13	17 4	71 14
VIII.	32	10	4	$1\frac{7}{8}$	$\frac{1}{4}$	8	80	7 2	14 6	1 1	22 9	70 8
X.	40	12	4	3	$\frac{1}{4}$	12	144	12 14	17 15	1 9	32 6	80 15
XII.	48	14	$4\frac{3}{4}$	3	$\frac{1}{2}$	14	196	17 8	21 9	1 15	41 0	85 7
XIV.	56	$16\frac{1}{2}$	$5\frac{1}{2}$	3	$\frac{1}{2}$	15	247·5	22 2	25 2	2 6	49 10	88 10
XVI.	64	$18\frac{1}{2}$	$6\frac{1}{8}$	$3\frac{5}{16}$	$\frac{5}{16}$	18	333	29 12	28 12	2 15	61 7	96 0
XVIII.	72	$20\frac{1}{2}$	$7\frac{1}{8}$	$3\frac{7}{8}$	$\frac{7}{16}$	24	492	43 15	32 5	3 13	80 1	111 3
XX.	80	$22\frac{1}{2}$	8	5	$\frac{7}{16}$	29	652·5	58 4	35 14	4 11	98 13	123 8

Note.—Calculated to support a load of 100 lbs. per square foot.

CXLV.—Belgaum Tiled Roof Covering.

Artificers, Labourers, and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Battens, teak ...R.F.	240	1 8 100	3 10			
Nails for battens and rafters	6	1 0 6 lbs.	1 0			
Flat tiles, "Sudda beelas," 5″×5″×½″...	650	4 0 1,000	2 10			
Round tiles 15½″×5½″ No.	440	11 0 1,000	4 13			
Lime, slaked ...C.F.	3	12 0 40 C.F.	0 14			
Sand ... ...C.F.	4½	2 0 100 C.F.	0 2			
Sundries		.....	0 4			
		Total Materials.	13 5			
Labour.						
Masons	3	0 8 each.	1 8			
Carpenter	1	0 12 do.	0 12			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisti	¼	0 8 do.	0 2			
Grinding chunam. C.F.	5	3 0 100 C.F.	0 3			
Sundries	...	.....	0 4			
		Total Labour ...	3 15			
Total for 100 S.F. of Roof Covering ...			17 4	Total for 100 S.F. of Roof Covering ...		

CXLVI.—Taylor's Tiles.

	£	s.	d.
Cost in England of dull red colour per 1,000	6	15	0
Hip, each working 12″ run	0	1	2
Pair of ridge, each working 15″ run...	0	1	5
Galvanized tile nails, one to each tile for 1,000	0	5	0

	Rs.	a.	p.
Freight from England to Bombay per 1,000 at 44 square yards to the ton, about	35	0	0

Extra tiles to be ordered out for breakage at 20 per cent.

Cost of laying on roofs in Bombay	2	5	0

Artificers, Labourers, and Materials for 100 Square Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount.	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Battens, teak, 3″ × ¾″, S.F. 120 or ... C.F.	1·87	3	0	C.F.	5	10						
Nails for battens and rafters... ... lbs.	5	1	0	6 lbs.	0	13						
Tiles, 12⅜″ × 8½″, including 20 per cent. for breakage	222	110	0	1,000	24	7						
Nails, galvanized ...	222	4	0	1,000	0	14						
Sundries	...	.....			0	8						
		Total Materials.			32	4						
Labour.												
Carpenter	1	0	12	each.	0	12						
Cooly	1	0	3	do.	0	3						
Laying tiles ... S.F.	100	2	5	100	2	5						
Sundries	...	.....			0	8						
		Total Labour ...			3	12						
Total for 100 S.F. Roof Covering ...					36	0		Total for 100 S.F. Roof Covering.				

CXLVI (*a*).—Taylor's Ridge or Hip.

Artificers, Labourers and Materials for 100 Running feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Ridge tiles ...Pairs	80	1 0 Pair	80 0			
Do. for breakage 20 per cent	16	1 0 do.	16 0			
		Total Materials.	96 0			
Labour.						
Fixing ... ... R.F.	100	8 6 100	8 6			
Sundries	...	.....	0 10			
		Total Labour ...	9 0			
Total for 100 Running Feet ...			105 0	Total for 100 R.F. ...		

Note.—Colonel Fuller's rate for tiles laid on roof (exclusive of all wood-work, rafters and battens or planking) including nails, hips, ridges, breakage, &c., is Rs. 32 per 100 S.F.

	Lbs.
Weight of Taylor's tiles, dry, per 100 S.F	674
Do. do. wet, do.	796
Do. of ordinary native tiles, single, dry, per 100 S.F	...1,312
Do. do. do. wet, do.	...1,462
Do. do. do. double, dry do.	...2,624
Do. do. do. wet do.	...2,924
Do. Mangalore tiles, dry, do.	... 722
Do. do. wet do.	... 844
Do. Belgaum roof covering dry, do.	...1,762

CXLVII.—Mangalore Tiles.

Artificers, Labourers and Materials for 100 Supl. Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Materials.												
Battens 1″ × 1¾″, 100 R. ft., or ... C.F.	1·25	3	0	C.F.	3	12						
Nails for rafters and battens ... lbs.	5	1	0	6 lbs.	0	13						
Tiles, 16″ × 9¼″, including 10 per cent. for breakage, in Mangalore	165	50	0	1,000	8	4						
Sundries	...	...		...	0	5						
		Total Materials.			13	2						
Labour.												
Freight to Bombay. No.	165	30	0	1,000	4	15						
Carpenter	1	0	12	each.	0	12						
Tile-layer	1	0	8	do.	0	8						
Coolies	2	0	3	do.	0	6						
Women	2	0	2	do.	0	4						
Sundries	...	...		...	0	4						
		Total Labour...			7	1						
Total for 100 Supl. Ft. Roof Covering...					20	3	Total for 100 Supl.Ft. Roof Covering...					

CXLVII. (*a*).—Mangalore Ridge Tiles.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Ridge tiles at Mangalore ... No.	110	50 0 1,000	5 8			
Lime ... C. F.	6	12 0 40 C. F.	1 13			
Sand ... C. F.	9	2 0 100 C. F.	0 3			
Sundries	...	... ...	0 4			
		Total Materials.	7 12			
Labour.						
Freight to Bombay ...	110	30 0 1,000	3 5			
Bricklayers... ...	3	0 10 each.	1 14			
Coolies	2	0 3 do.	0 6			
Women	2	0 2 do.	0 4			
Grinding chunam. C. F.	9	3 0 100 C. F.	0 4			
Sundries	...	... ...	0 4			
		Total Labour...	6 5			
		Total for 100 R.F....	14 1		Total for 100 R.F....	

CLV.—Gutters and Valleys of Sheet Lead.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C.F.	23	3 0 C. F.	69 0			
Sheet lead, 6 lbs. to the square foot ... Cwt.	16	17 8 Cwt.	280 0			
Sundries, such as nails, &c.	...	... ...	1 0			
		Total Materials.	350 0			
Labour.						
Carpenters	10	0 12 each.	7 8			
Coolies	10	0 3 do.	1 14			
Sundries	...	... ...	0 10			
		Total Labour...	10 0			
Add.						
Dammering to wood-work	...	... ...	5 0			
Total for 100 Running Feet...			365 0	Total for 100 Running Feet... ...		
Or per Running Foot...			3 10	Or per Running Foot		

CLVI.—Valleys of Sheet Iron.

Artificers, Labourers, and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Teakwood ... C. F.	23	3 0 C.F.	69 0			
Sheet iron 110′ × 3′ × $\frac{1}{16}$″ Cwt.	7½	14 0 Cwt.	105 0			
Charcoal ... lbs.	240	1 0 80 lbs.	3 0			
Sundries	...	.....	1 0			
		Total Materials.	178 0			
Labour.						
Carpenters	6	0 12 each.	4 8			
Coolies	6	0 3 do.	1 2			
Smiths	6	0 12 do.	4 8			
Bellows-boys	6	0 4 do.	1 8			
Sundries	...	.. ...	0 6			
		Total Labour...	12 0			
Add.						
Dammering to wood and iron	...	.....	10 0			
Total for 100 Running Feet ...			200 0	Total for 100 Running Feet		
Or per Running Foot...			2 0	Or per Running Foot		

VIII.—ROAD-WORK SPECIFICATIONS.

	Page.
CLX.—Excavation in Black Soil	229
CLXI.— Do. Soft Moorum	230
CLXII.— Do. Average do.	231
CLXIII.— Do. Hard do.	232
CLXIV.— Do. Loose Earth	233
CLXV.— Do. Soft Rock	234
CLXVI.— Do. Hard do.	234
CLXVII.—Moorum, digging, &c.	235
CLXVIII.— Do. watering and rolling	236
CLXIX.—Metal from boulders	237
CLXX.— Do. blasted rubble	237
CLXXI.— Do. carrying and stacking	238
CLXXII.— Do. spreading	239
CLXXIII.— Do. consolidating	239
CLXXIV.— Do. (steam rollers)	240

CLX to CLXXIV.

See General Specifications No. VII. at page 7.

NOTES.

Note (1).—Detailed Rates Nos. CLX. to CLXIV. are based on the Tables of task work circulated with G. R. No. 64, dated 14th January 1882, but modified slightly so as to give the cost of embankments and cuttings in ordinary road works. The tasks have been reduced about 14 per cent.

(2).—Detailed Rates Nos. CLXV. and CLXVI. are for *general excavation* in soft and hard rock, and would not apply, for instance, in the case of the excavation of a well of small diameter, or any considerable depth.

(3).—The cost of conveyance to road side in the case of long leads adds very materially to the cost of either moorum or metal at quarry site. This may, however, be ascertained for any lead up to 10 miles by the assistance of the Tables for calculating cost of conveying materials by carts or coolies. (See Section XII. further on.)

CLX.—Excavation in Black or Red Soil.

Lead in Feet.		Lift in Feet.	Cost per 100 Cubic Feet.								
From	To		Labour.			Establishment.			Sundries.			Total.		
			Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.
0	50	0 to 5	0	4	7	0	0	5	0	1	0	0	6	0
50	100		0	5	0	0	0	5	0	1	0	0	6	5
100	200		0	5	5	0	0	6	0	1	0	0	6	11
200	300		0	6	0	0	0	6	0	1	0	0	7	6
300	400		0	6	8	0	0	7	0	1	0	0	8	3
400	500		0	7	4	0	0	8	0	1	0	0	9	0
500	600		0	8	4	0	0	9	0	1	0	0	10	1
0	100	5 to 10	0	6	3	0	0	6	0	1	0	0	7	9
100	200		0	6	10	0	0	7	0	1	0	0	8	5
200	300		0	7	4	0	0	8	0	1	0	0	9	0
300	400		0	7	11	0	0	8	0	1	0	0	9	7
400	500		0	8	10	0	0	9	0	1	0	0	10	7
500	600		0	10	0	0	0	10	0	1	0	0	11	10
0	100	10 to 15	0	7	14	0	0	8	0	1	6	0	9	6
100	200		0	7	11	0	0	8	0	1	6	0	10	1
200	300		0	8	7	0	0	9	0	1	6	0	10	10
300	400		0	9	1	0	0	9	0	1	6	0	11	4
400	500		0	10	4	0	0	11	0	1	6	0	12	9
500	600		0	11	6	0	1	0	0	1	6	0	14	0
0	100	15 to 20	0	8	4	0	0	9	0	1	6	0	10	7
100	200		0	9	1	0	0	9	0	1	6	0	11	4
200	300		0	9	8	0	0	10	0	1	6	0	12	0
300	400		0	10	9	0	0	11	0	1	6	0	13	2
400	500		0	11	6	0	1	0	0	1	6	0	14	0
500	600		0	13	1	0	1	1	0	1	6	0	15	8

N.B.—The above Table is calculated on the assumption that the ordinary daily pay of a cooly is 3 annas.

CLXI.—Excavation in Soft Moorum.

Lead in Feet.		Lift in Feet.	Cost per 100 Cubic Feet.								
From	To		Labour.			Establishment.			Sundries.			Total.		
			Rs.	a.	p.	Rs.	a	p.	Rs.	a.	p.	Rs.	a.	p.
0	50	0 to 5	0	5	8	0	0	6	0	1	0	0	7	2
50	100		0	6	1	0	0	6	0	1	0	0	7	7
100	200		0	6	8	0	0	7	0	1	0	0	8	3
200	300		0	7	4	0	0	8	0	1	0	0	9	0
300	400		0	8	4	0	0	8	0	1	0	0	10	0
400	500		0	8	10	0	0	9	0	1	0	0	10	7
500	600		0	10	0	0	0	11	0	1	0	0	11	11
0	100	5 to 10	0	7	8	0	0	8	0	1	0	0	9	4
100	200		0	8	4	0	0	9	0	1	0	0	10	1
200	300		0	8	10	0	0	9	0	1	0	0	10	7
300	400		0	9	8	0	0	10	0	1	0	0	11	6
400	500		0	10	9	0	0	11	0	1	0	0	12	8
500	600		0	12	0	0	1	1	0	1	0	0	14	1
0	100	10 to 15	0	8	10	0	0	9	0	1	6	0	11	1
100	200		0	9	8	0	0	10	0	1	6	0	12	0
200	300		0	10	4	0	0	11	0	1	6	0	12	9
300	400		0	11	1	0	1	0	0	1	6	0	13	7
400	500		0	12	6	0	1	1	0	1	6	0	15	1
500	600		0	14	3	0	1	3	0	1	6	1	1	0
0	100	15 to 20	0	10	0	0	0	11	0	1	6	0	12	5
100	200		0	11	1	0	1	0	0	1	6	0	13	7
200	300		0	12	0	0	1	0	0	1	6	0	14	6
300	400		0	13	1	0	1	2	0	1	6	0	15	9
400	500		0	14	3	0	1	3	0	1	6	1	1	0
500	600		0	15	10	0	1	5	0	1	6	1	2	9

N.B.—The above Table is calculated on the assumption that the ordinary daily pay of a cooly is 3 annas.

CLXII.—Excavation in Average Moorum.

Lead in Feet.		Lift in Feet.	Cost per 100 Cubic Feet.			
From	To		Labour.	Establishment.	Sundries.	Total.
			Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
0	50	0 to 5	0 7 2	0 0 8	0 1 3	0 9 0
50	100		0 7 11	0 0 7	0 1 3	0 9 10
100	200		0 8 7	0 0 9	0 1 3	0 10 7
200	300		0 9 5	0 0 10	0 1 3	0 11 6
300	400		0 10 4	0 0 11	0 1 3	0 12 6
400	500		0 11 6	0 1 0	0 1 3	0 13 9
500	600		0 13 1	0 1 1	0 1 3	0 15 5
0	100	5 to 10	0 9 8	0 0 10	0 1 3	0 11 9
100	200		0 10 9	0 0 11	0 1 3	0 12 7
200	300		0 11 6	0 1 0	0 1 3	0 13 9
300	400		0 12 6	0 1 1	0 1 3	0 14 10
400	500		0 13 8	0 1 2	0 1 3	1 0 1
500	600		0 15 10	0 1 4	0 1 3	1 2 5
0	100	10 to 15	0 11 6	0 1 0	0 1 9	0 14 3
100	200		0 12 6	0 1 1	0 1 9	0 15 4
200	300		0 13 8	0 1 2	0 1 9	1 0 7
300	400		0 14 3	0 1 3	0 1 9	1 1 3
400	500		0 15 10	0 1 5	0 1 9	1 3 0
500	600		1 1 8	0 1 7	0 1 9	1 5 0
0	100	15 to 20	0 13 1	0 1 2	0 1 9	1 0 0
100	200		0 14 3	0 1 3	0 1 9	1 1 3
200	300		0 15 0	0 1 4	0 1 9	1 2 1
300	400		1 0 8	0 1 5	0 1 9	1 3 10
400	500		1 1 8	0 1 7	0 1 9	1 5 0
500	600		1 4 0	0 1 9	0 1 9	1 7 6

N.B.—The above Table is calculated on the assumption that the ordinary daily pay of a cooly is 3 annas.

CLXIII.—Excavation in Hard Moorum.

Lead in Feet.		Lift in Feet.	Cost per 100 Cubic Feet.			
From	To		Labour.	Establishment.	Sundries.	Total.
			Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
0	50	0 to 5	0 10 0	0 0 10	0 1 6	0 12 4
50	100		0 10 9	0 0 11	0 1 6	0 13 2
100	200		0 12 0	0 1 0	0 1 6	0 14 6
200	300		0 13 1	0 1 2	0 1 6	0 15 9
300	400		0 14 3	0 1 3	0 1 6	1 1 0
400	500		0 15 10	0 1 5	0 1 6	1 2 9
500	600		1 1 8	0 1 7	0 1 6	1 4 9
0	100	5 to 10	0 13 8	0 1 2	0 1 6	1 0 4
100	200		0 15 0	0 1 3	0 1 6	1 1 9
200	300		0 15 10	0 1 5	0 1 6	1 2 9
300	400		1 1 8	0 1 6	0 1 6	1 4 8
400	500		1 2 9	0 1 8	0 1 6	1 5 11
500	600		1 5 5	0 1 11	0 1 6	1 8 10
0	100	10 to 15	0 15 10	0 1 5	0 2 0	1 3 3
100	200		1 1 8	0 1 6	0 2 0	1 5 2
200	300		1 2 9	0 1 7	0 2 0	1 6 4
300	400		1 4 0	0 1 8	0 2 0	1 7 8
400	500		1 7 1	0 1 11	0 2 0	1 11 0
500	600		1 9 0	0 2 2	0 2 0	1 13 2
0	100	15 to 20	1 1 8	0 1 7	0 2 0	1 5 3
100	200		1 4 0	0 1 8	0 2 0	1 7 8
200	300		1 5 5	0 1 10	0 2 0	1 9 3
300	400		1 7 1	0 2 0	0 2 0	1 11 1
400	500		1 9 0	0 2 2	0 2 0	1 13 2
500	600		1 11 3	0 2 6	0 2 0	1 15 9

N.B.—The above Table is calculated on the assumption that the ordinary daily pay of a cooly is 3 annas.

CLXIV.—Excavation in Loose Earth or Sand.

Lead in Feet.		Lift in Feet.	Cost per 100 Cubic Feet.								
From	To		Labour.			Establishment.			Sundries.			Total.		
			Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.	Rs.	a.	p.
0	50	0 to 5	0	3	8	0	0	4	0	1	0	0	5	0
50	100		0	4	0	0	0	4	0	1	0	0	5	4
100	200		0	4	4	0	0	5	0	1	0	0	5	9
200	300		0	4	9	0	0	5	0	1	0	0	6	2
300	400		0	5	4	0	0	6	0	1	0	0	6	10
400	500		0	5	11	0	0	6	0	1	0	0	7	5
500	600		0	6	8	0	0	7	0	1	0	0	8	3
0	100	5 to 10	0	5	0	0	0	5	0	1	0	0	5	5
100	200		0	5	5	0	0	6	0	1	0	0	6	11
200	300		0	5	11	0	0	6	0	1	0	0	7	5
300	400		0	6	3	0	0	7	0	1	0	0	7	10
400	500		0	7	0	0	0	7	0	1	0	0	8	7
500	600		0	7	11	0	0	8	0	1	0	0	9	7
0	100	10 to 15	0	5	11	0	0	6	0	1	6	0	7	11
100	200		0	6	3	0	0	7	0	1	6	0	8	4
200	300		0	6	10	0	0	7	0	1	6	0	8	11
300	400		0	7	4	0	0	8	0	1	6	0	9	6
400	500		0	8	4	0	0	9	0	1	6	0	10	7
500	600		0	9	1	0	0	10	0	1	6	0	11	5
0	100	15 to 20	0	6	8	0	0	7	0	1	6	0	8	9
100	200		0	7	4	0	0	8	0	1	6	0	9	6
200	300		0	7	8	0	0	8	0	1	6	0	9	10
300	400		0	8	7	0	0	9	0	1	6	0	10	10
400	500		0	9	1	0	0	10	0	1	6	0	11	5
500	600		0	10	4	0	0	11	0	1	6	0	12	9

N.B.—The above Table is calculated on the assumption that the ordinary daily pay of a cooly is 3 annas.

CLXV.—Excavation in Soft Rock.

Materials and Labour per 100 Cubic Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Miners...	2	0	4	each.	0	8						
Coolies	4	0	3	do.	0	12						
Women	2	0	2	do.	0	4						
Smith and Bellows-boy	¼	1	0	do.	0	4						
Sundries	...	.....			0	4						
Total for 100 C.F. ...					2	0		Total for 100 C.F.				

CLXVI.—Excavation in Hard Rock.

Materials and Labour for 100 Cubic Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Miners...	6	0	4	each.	1	8						
Coolies...	4	0	3	do.	0	12						
Women	2	0	2	do.	0	4						
Smith...	½	0	12	do.	0	6						
Bellows-boy	½	0	4	do.	0	2						
Hammer-man... ...	½	0	6	do.	0	3						
Blasting powder. lbs.	10	1	0	5 lbs.	2	0						
Charcoal ... lbs.	15	1	0	80 lbs.	0	3						
Steel and Sundries ...	...	.....			0	6						
Total for 100 C.F. ...					5	12		Total for 100 C.F.				

CLXVII.—Moorum for Road Surface.

Materials and Labour for 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Digging and stacking at the Quarry for hard moorum ...	...	.....	1 0			
* Conveying and stacking at the roadside up to ½ a mile ...	...	.....	...			
Cart ... ...No.	1	0 12 each.	0 12			
Coolies ...	¼	0 3 do.	0 ¾			
Women ...	¼	0 2 do.	0 ½			
Sundries ...	...	.....	0 ¾			
For every additional ½ mile add 1 cart ...	...	.....	...			
Total for 100 C.F. stacking at roadside. ...		.....	0 14		Total for 100 C.F. stacking at roadside	
Spreading Moorum.						
Coolies...	½	0 3 each.	0 1½			
Women	1	0 2 do.	0 2			
Sundries	...	.....	0 ½			
Total for 100 C.F. spreading moorum ...			0 4		Total for 100 C.F. spreading moorum.	

* *Note.*—For cost of conveyance by carts or coolies for any lead up to 10 miles see Tables of cart and coolie-hire in Section XII further on.

CLXVIII.—Watering and Rolling Moorum for Road Surface.

Materials and Labour for 1 mile of road, coating 3″ thick and 20′ wide.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Watering.						
Water carts	28	0 12 each	21 0			
Coolies	28	0 3 do.	5 4			
Sundries		.....	1 4			
		Total Watering.	27 8			
Rolling.						
Bullocks ... pairs.	28	0 12 each	21 0			
Coolies ... No.	14	0 3 do.	2 10			
Sundries		.....	3 6			
		Total Rolling ...	27 0			
Total for watering and rolling per mile.			54 8		Total for watering & rolling per mile...	

Note.—A 3-feet or 2-ton roller drawn by 4 pairs of bullocks will travel about 10 miles a day over new moorum surface; the above allows for a roller, 3′ long, passing 10 times over the whole; therefore 7 days are required for consolidation. 4 carts would be required to keep the surface properly watered if the water is not brought from a distance exceeding ½ a mile. For a 6″ or 8″ coat of moorum take 1½ times the above.

CLXIX.—Stone Metal from Boulders.

Materials and Labour for 100 Cubic Feet of 1½″ Metal.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Coolies for quarrying ... ... No.	2	0 4 each.	0 8			
Hammer-man... ...	1	0 6 do.	0 6			
Women for breaking...	12	0 2 do.	1 8			
Sundries	...	.....	0 2			
Total for breaking per 100 Cubic Feet ...			2 8	Total for breaking per 100 C. F. ...		

CLXX.—From Blasted Rubble.

Materials and Labour for 100 Cubic Feet of 1½″ Metal.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Labour.						
Hammer-man ...No.	1	0 6 each.	0 6			
Women for breaking...	10	0 2 do.	1 4			
Smith do. ...	...	.....	0 2			
		Total Labour...	1 12			
Materials.						
Rubble Stone ...C. F.	100	3 0 100 C.F.	3 0			
Sundries	...	.....	0 2			
		Total Materials.	3 2			
Total for breaking per 100 Cubic Feet...			4 14	Total for breaking per 100 C. F.		

CLXXI.—Carrying and Stacking Metal.

Materials and Labour for 100 Cubic Feet of 1½″ Metal.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a		Rs. a. Per	Rs. a.
**Carrying to a distance of ½ mile and stacking by roadside.*						
Cart ... ... No.	1	0 12 each.	0 12			
Coolies	½	0 3 „	0 1½			
Women	½	0 2 „	0 1			
Sundries	...	.....	0 1½			
Total for 100 C.F. ...			1 0	Total for 100 C.F.		

For every additional ½ mile road add 1 cart.

Note.—An ordinary country cart can carry a load of about 8 cwts. a distance of 7 miles and return empty the same day.

* *Note.*—For cost of conveyance by carts or coolies for any lead up to 10 miles, see Tables of cart and coolie hire in Section XII further on.

Note.—From some experiments made by the compiler it would appear that trap weighing 180 lbs. per cubic foot when broken into metal weighs about 96 lbs. per cubic foot. As a general rule, metal weighs 50 per cent. less than the weight of the stone itself. Laterite metal broken to pass through a 2½ inch ring weighs about 77 lbs. per cubic foot.

CLXXII.—Picking up Surface and Spreading.

Materials and Labour for 100 Cubic Feet of 1½″ Metal.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Spreading.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Coolies ... ... No.	1	0 3 each.	0 3			
Women	2	0 2 do.	0 4			
Sundries	...	.....	0 1			
		Total per 100 C.F	0 8		Total per 100 C.F.	
Picking up surface.						
Coolies per 100 Supl. ft...	½	0 3 each.	0 1½			
		Total for 100 Supl. Feet...	0 3½		Total for 100 Supl. Feet.	

CLXXIII.—Consolidating.

By rolling with bullocks.

Materials and Labour for 1 mile of road 18′ wide 3″ including watering.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Bullocks, pairs	105	0 12 each	78 12			
Watering carts	42	0 12 do.	31 8			
Coolies	63	0 3 do.	11 13			
Sundries	...	.....	2 1			
		Total consolidating ...	124 9		Total consolidating	

Note.—This rate is framed on the assumption that a 2-ton roller will travel about 7 miles per day on new metal surface when drawn by 5 pairs of bullocks, and that at least 25 turns in each part of the surface should be given.

CLXXIV.—Steam Rolling with 15-ton Roller.

For one Mile.

Materials and Labour for 1 mile of road 15′ wide and 6″ thick.	Number or quantity.	Rate.	Amount.	Number or quantity.	Rate.	Amount.
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Steam roller working, days.	20	17 0 each	*340 0			
Repairs and depreciation ... ... days.	20	2 0 do.	40 0			
		Total per mile ...	380 0		Total per mile ...	

* The rate is given by the Executive Engineer, Poona and Kirkee, and the details of the charge, Rs. 17 per day, are as follows :—

No.	Items.	Number or quantity.	Rate.	Per	Amount.
	Labour.		Rs. a. p.		Rs. a. p.
1	Native Driver	1	40 0 0	Month.	1 5 4
1	Brakeman	1	15 0 0	Do.	0 8 0
1	Fireman	1	12 0 0	Do.	0 6 5
1	Cooly at night	1	0 3 0	Day.	0 3 0
2	Flag boys	2	0 2 0	Do.	0 4 0
2	Bhisties	2	0 6 0	Do.	0 12 0
1	Cart to convey firewood and coals, &c.	½	0 10 0	Do.	0 5 0
				Total Labour ...	3 11 9
	Materials.				
	Firewood ... ... Maund.	1	0 10 0	Maund.	0 10 0
	English coal ... ... do.	12	1 0 0	Do.	12 0 0
	Castor oil ... ... lbs.	1½	0 2 6	Lb.	0 3 9
	Cotton waste .. .. do.	¼	0 4 0	Do.	0 1 0
	Tallow ... ... do.	¼	0 4 0	Do.	0 1 0
	Soap	...	.....	...	0 0 6
				Total Materials ...	13 0 3
				Total Rs. ...	17 0 0

The roller is worked by a 6″ H. P. engine, and kept working 9 hours.

Contract Rates for Road Repairs in Poona and Kirkee Cantonment in 1886-87.

Metal... ...	...	Rs.	4 4 0	per 100 C.F.
Spreading ...	...	,,	0 8 0	,,
Sand	...	,,	2 3 6	,,
Spreading ...	..	,,	0 3 4	,,
Picking up road surface	...	,,	0 1 6	per 100 S.F.

IX.—MISCELLANEOUS.

	Page
CLXXV.—String Course, cut stone, 1st Sort	243
CLXXVI.— Do. do. do. 2nd do.	243
CLXXVII.—Coping, cut stone, rectr., 1st do.	243
CLXXVIII.— Do. do. do. 2nd do.	243
CLXXIX.— Do. do. semi-octl., 1st do.	243
CLXXX.— Do. do. do. 2nd do.	243
CLXXXI.— Do. do. semicircular, 1st do.	243
CLXXXII.— Do. do. do. 2nd do.	243
CLXXXIII.—Stone Steps	243
CLXXXIV.—Stone Stairs	243
CLXXXV.—Wooden stair-case	244
CLXXXVI.—Painting	244
CLXXXVII.—Varnishing	245
CLXXXVIII.—White-washing...	245
CLXXXIX.—Yellow-washing	245
CXC.—Blue-washing	245
CXCI.—Pink-washing	245
CXCII.—Green-washing	245
CXCIII.—Papering	245
CXCIV.—Glazing	246
CXCV.—Tile skirting	246
CXCVI.—Galvanized Iron Wire Netting	246
CXCVII.—Hoop Iron Trellis Work	246
CXCVIII.—Teakwood do. do.	246
CXCIX.—Laying Cast-iron Pipes, 10″ diameter... ...	246
CC.— Do. do. do. 6″ do.	246
CCI.— Do. do. do. 4″ do.	246
CCII.— Do. do. do. 3″ do.	246
CCIII.—Grinding Mortar	270
CCIV.—Tile making	270
CCV.—Brick-making on tables	271
CCVI.— Do. do. on ground	272
CCVII.—Lime-burning with Charcoal	273
CCVIII.— Do. do. with firewood	274
CCIX.— Do. do. with English coal	275
CCX.—Wire Fencing	276
CCXI.—Laterite and Lime Foundation	277
CCXII.— Do. do. Plinth	278
CCXIII.— Do. Superstructure	279
CCXIV.— Do. Arching	280
CCXV.— Do. Paving	281
CCXVI.— Do. Cornice, 8″ high	282
CCXVII.— Do. Coping semi-octl. top	283
CCXVIII.— Do. Concrete	284
CCXIX.—Laterite Metal from Boulders	284

IX.—MISCELLANEOUS.

CLXXV. to CLXXXII.—String Courses and Copings.

Dressing and joints.

1. All cut stone in string courses, copings, &c., to be worked to such sizes, sections, or shapes as shown in working drawings, or as required by the design. The stones to be fine-dressed on face and joints, and rough tooled on beds, full, true, and out of winding. The joints to be true and close, and not to exceed $\frac{1}{8}''$. All visible edges and angles to be quite free from unsightly chippings.

Size of stones.

2. No stone to be less in any dimension than its height.

Corbels.

3. All projecting stones, such as corbels, &c., to tail and bed back into the work at least twice the length of its entire projection, and at least $1\frac{1}{2}$ times its own height.

Note—In string courses and copings, 2nd sort, the faces need only be rough tooled, and joints not to exceed $\frac{1}{4}$ inch in thickness.

CLXXXIII.—Stone Steps.

Dressing.

1. To be of such shapes or sizes as may be shown on the drawings, and dressed on surface and joints as for paving 1st, 2nd, or 3rd sorts. (See specification Nos. LX., LXI. and LXII.

Size and over lap.

2. The stones to lap uniformly for at least $1\frac{1}{2}''$, and when laid between walls to tail into the walls at least $1\frac{1}{2}''$. Every stone to be of the full breadth of the tread and lap and height of riser.

CLXXXIV.—Stone Stairs.

Dressing.

1. The stone to be fine chisel-dressed on all exposed faces, and of such shapes and sizes as may be shown in the drawings.

Nosings.

2. The steps to be of single stones, and to have mouldings and nosings returned at the ends (unless otherwise specified). The soffits to be dressed fair and sloped off.

Curtail.

3. The bottom step to be finished with a proper curtail.

Side wall.

4. When the steps rest on side walls or girders, they are to be solidly bedded, and to run into the wall at least 3 inches. When the stairs are geometrical, the stones are to run into the wall half its thickness, or at least 9 inches.

Lap.

5. They are to be back-jointed as shown in drawing, and to bear on each other at least $\frac{1}{2}''$ per foot in length of step.

6. The stones are to be laid on proper centres, which shall not be removed without permission nor till the baluster holes are cut.

Centres.

CLXXXV.—Wooden Staircase.

1. To be of best Moulmein teak, with risers $1\frac{1}{4}''$ thick, tongued and grooved top and bottom into treads $1\frac{3}{4}''$ thick, with moulded nosings along the fronts and returns.

Risers and Treads.

2. The soffits to be boarded with $\frac{3}{4}''$ teak planks framed with V joints, or tongued and grooved.

Soffits.

3. The steps to be properly framed into the inner and outer strings which are to be $14'' \times 3''$.

Strings.

4. Landings to have nosing and soffit corresponding to steps.

Landing.

5. The bottom steps to be finished with a proper curtail.

Curtail.

6. The steps to be supplied with teak hand rail and balusters of the pattern shown in drawings, properly fixed into treads.

Balusters and hand rail.

Note.—The following rule is often adopted for steps of the dimensions ordinarily required in practice, *i.e.* those with treads from 9 to 14 inches wide.

Width of tread × height of riser = 66 inches, or for *any* width of tread the following :—

The width of tread added to twice the height of the rise should be equal to 23 inches.

CLXXXVI.—Painting.

1. All wood and iron work exposed to the weather will receive 4 coats of paint: if in the interior of a building 3 coats will suffice. Paint should not be applied to wood-work unless it is well seasoned.

Number of coats.

2. Surfaces to be painted or varnished, to be thoroughly dry, clean, and smoothed, free from rust and dirt.

Cleaning.

3. After priming coat in which no colouring matter need be put, all holes, cracks, &c., to be stopped with putty and all knots to be properly killed.

Priming coat.

4. The paint to be thoroughly ground up in oil and mixed with the proper proportion of double boiled linseed oil and spirits of turpentine. Mineral turpentine on no account to be used.

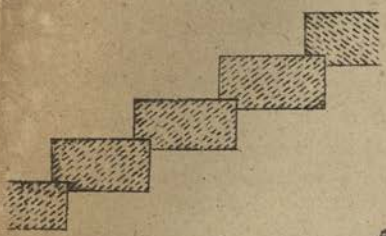
Mixing.

Note.—For proper proportion of linseed oil and turpentine in the different coats, see Notes on Paints, Washes, and Varnishes in Section X further on.

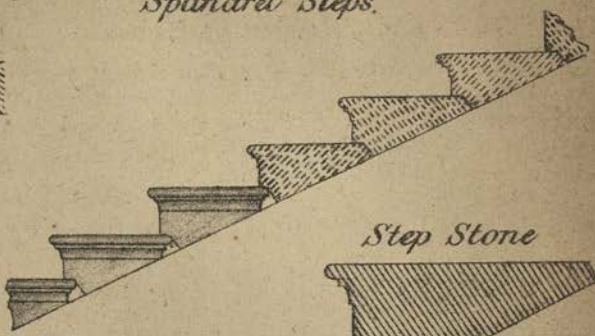
Plate XIX.

Steps and Stairs.

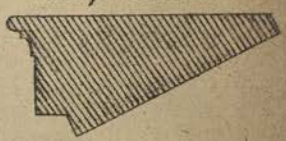
Square Steps



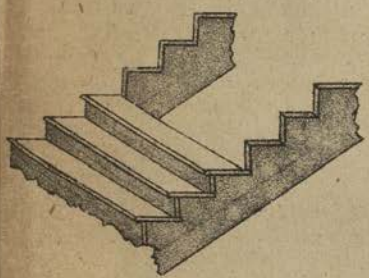
Spandrel Steps.



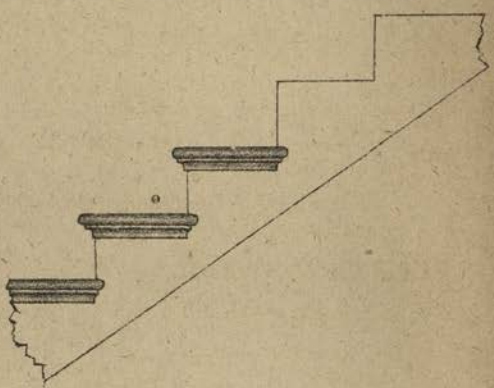
Step Stone



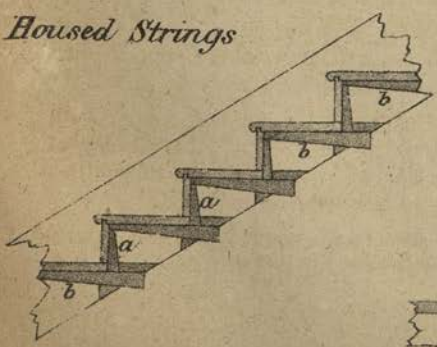
Cut Strings



Cut and Mitred Strings

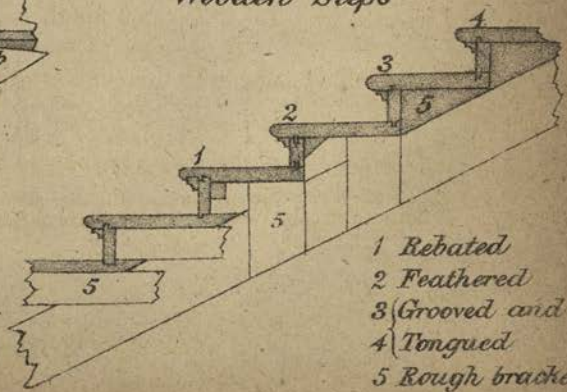


Housed Strings



a } Wedges
b }

Wooden Steps



1 Rebated
2 Feathered
3 } Grooved and
4 } Tongued
5 Rough brackets

Govt Photozinco Office Poona 1887

5. For fine work each coat should be carefully rubbed down with pumice stone, or glass paper, and dusted before the next coat is added.

Fine work.

CLXXXVII.—Varnishing.

1. The wood-work when cleaned and rubbed down, to receive two coats of clean boiled linseed oil, or two coats of size laid on at sufficient intervals of time. When dry the varnish is to be smoothly laid on in thin coats.

Preparing surface.

2. The varnish used to be the best English copal, unless otherwise specified.

Copal varnish.

CLXXXVIII. to CXCII.—White-washing and Colour-washing.

1. To be prepared from fresh burnt white stone lime. The lime to be dissolved in a tub with a sufficient quantity of water, and the whole well mixed; when thoroughly mixed to be strained through a clean cloth; clean gum dissolved in hot water to be then added in the proportion of 2 oz. of gum arabic to 1 cubic foot of lime, or rice size may be used in place of gum.

White-washing.

2. Each coat to be laid on with a brush; one coat with a stroke of the brush from the top downwards, another from the bottom upwards over the first stroke, and similarly one stroke from the right and another from the left over the first brush before it dries. Three coats to be applied.

3. Before whitewash is laid on the surface of new walls, the walls to be well cleaned and brushed.

4. On walls which have been once whitewashed, the old loose whitewash to be first removed and the plaster repaired.

Note.—For the proportion of ingredients for different descriptions of colourwashing *see* Notes on Paints, Washes, Varnishes, &c., in Section X further on, and in Rates for the same from page 256 to 262.

CXCIII.—Papering.

1. The paper to be of an approved pattern.

Pattern.

2. The walls to be properly scraped and rubbed down quite free from any colour-wash or dirt. The walls should then be sized with parchment size or rice congee.

Cleaning and sizing.

3. If expensive paper is used, the walls to be first covered with a coating of lining paper. Wall to be quite dry before the paper is applied.

Lining paper.

4. The paper to be applied with paste made of best wheat flour and water, a little size or glue, blue stone (sulphate of copper) being added to prevent the attacks of insects. A little alum may also be added to make the paste spread and flow more easily.

Paste.

5. The paper when applied to the wall to be smoothed down by a roller covered with clean flannel, and not by the hand, as the latter method completely ruins any delicate paper.

Roller.

CXCIV.—Glazing.

1. Glass to frames of windows and doors to be of good, clear, English crown glass, 21 oz., free from flaws or bubbles, properly cut, truly bedded flush in soft putty, sprigged in with proper glazing sprigs, and firmly back puttied with good putty of whiting and linseed oil.

Glass.

2. The putty to consist of equal parts of pure linseed oil and whiting well mixed up by hand, and to be coloured to suit the appearance of the woodwork.

Putty.

CXCV.—Tile Skirtings.

1. To be of Minton's or Maw's plain skirting tiles, of such colour as may be directed, set in Portland Cement; projecting $\frac{1}{4}''$ from the surface of the plastering.

CXCVII.—Hoop Iron Trellis Work.

1. To consist of Hoop Iron, 1 inch broad, 18 B. W. G., weighing 1·6 lbs. per ten lineal feet, interlaced diagonally at a pitch of 45°, leaving clear openings of 2 inches square. To be secured to a light frame work of teakwood. The whole to be painted on both sides with two coats of green or other paint.

Description.

CXCVIII.—Teakwood Trellis Work.

1. Teak battens $1'' \times \frac{1}{2}''$ to be crossed diagonally in opposite directions at an angle of 45°, leaving two inch square openings between them. To be secured to the verandah posts and post plates where such exist, or to a light frame-work of teakwood. To be painted on both sides.

Descriptions.

CXCIX to CCII.—Laying Cast-iron Pipes.

See Irrigation Specification No. XXX; also Notes on Work, Pipe-laying, for weight and thickness of iron pipes.

PROBABLE COST OF EXECUTING WORKS ACCORDING TO THE ABOVE SPECIFICATIONS.

CLXXV.—String Course, Cutstone, 1st Sort. 6″ high, 4″ projection dressed fine.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate				Amount		No. or quantity.	Rate.		Amount	
Materials.		Rs.	a.		Per	Rs.	a.		Rs.	a. Per	Rs.	a.
Stones, roughly dressed ... ... Sq. F.	125	0	4		foot	31	4					
Lime, slaked ... C. F.	6	12	0	40	C. F.	1	13					
Sand, fine ... C. F.	6	2	0	100	C. F.	0	2					
Charcoal ... lbs.	75	1	0	80	lbs.	0	15					
Iron ... lbs.	4	1	0	8	lbs.	0	8					
Sundries	...		.....			0	12					
		Total Materials.				35	6					
Labour.												
Masons, for dressing...	20	0	12		day.	15	0					
Do. setting ...	12	0	12		do.	9	0					
Nowgunnies	4	0	5		do.	1	4					
Coolies...	2	0	3		do.	0	6					
Women	6	0	2		do.	0	12					
Smiths...	1¼	0	12		do.	0	15					
Bellows-boys	1¼	0	4		do.	0	5					
Bhisties	¼	0	8		do.	0	2					
Grinding chunam C. F.	6	4	0	100	C. F.	0	4					
Scaffolding			.....			1	0					
Sundries			.....			0	12					
		Total Labour...				29	12					
Total for 100 R. F. ...						65	2		Total for 100 R. F.			

CLXXVI.—String Course, Cutstone, 2nd Sort.
Same as above.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Stones, roughly dressed ... ... Sq. F.	125	0 4 foot.	31 4			
Lime, slaked C. F.	10	12 0 40 C. F.	3 0			
Sand ... C. F.	15	2 0 100 C. F.	0 5			
Charcoal ... lbs.	60	1 0 80 lbs.	0 12			
Iron, &c. ... lbs.	3	1 0 8 lbs.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	36 7			
Labour.						
Masons, for dressing ...	12	0 12 each	9 0			
Do. setting ...	10	0 12 do.	7 8			
Nowgunnies ...	4	0 5 do.	1 4			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	¼	0 8 do.	0 2			
Smiths...	1	0 12 do.	0 12			
Bellows-boys	1	0 4 do.	0 4			
Grinding chunam C. F.	15	3 0 100 C. F.	0 7			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 12			
		Total Labour...	22 3			
		Total for 100 R. F. ...	58 10		Total for 100 R. F...	

CLXXVII.—Coping, Cutstone, rectangular, 1st Sort. 9″ high and 1-9″ width.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, rough ...C.F.	131	0 6 C. F.	49 2			
Lime, slaked C. F.	10	12 0 40 C.F.	3 0			
Sand, fine ... C. F.	10	2 0 100 C.F.	0 3			
Charcoal ... lbs.	160	1 0 80 lbs.	2 0			
Iron ... ... lbs.	8	1 0 8 lbs.	1 0			
Sundries	...	.....	1 0			
		Total Materials.	56 5			
Labour.						
Masons, for dressing...	80	0 12 each.	60 0			
Do. setting ...	12	0 12 do.	9 0			
Nowgunnies	12	0 5 do.	3 12			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	¼	0 8 do.	0 2			
Smiths	3	0 12 do.	2 4			
Bellows-boys	3	0 4 do.	0 12			
Grinding chunam C.F.	10	4 0 100 C.F.	0 6			
Scaffolding	...	.....	1 0			
Sundries	...	.....	1 0			
		Total Labour...	79 6			
		Total for 100 R. F. ...	135 11		Total for 100 R. F.	

CLXXVIII.—Coping, Cutstone, rectangular, 2nd Sort.

Same as above.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, rough ...C. F.	131	0 6 foot	49 2			
Lime, slaked ... C. F.	12	12 0 40 C. F.	3 10			
Sand ... ...C. F.	18	2 0 100 C. F.	0 6			
Charcoal ... ... lbs.	120	1 0 80 lbs.	1 8			
Iron ... ... lbs.	8	1 0 8 lbs.	1 0			
Sundries	...	.....	1 0			
		Total Materials.	56 10			
Labour.						
Masons, for dressing ...	50	0 12 each.	37 8			
Do. setting ...	10	0 12 do.	7 8			
Nowgunnies	12	0 5 do.	3 12			
Coolies...	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Smiths...	2	0 12 do.	1 8			
Bellows-boys	2	0 4 do.	0 8			
Grinding chunam C.F.	18	3 0 100 C. F.	0 9			
Scaffolding	...	.....	1 0			
Sundries	...	.....	1 0			
		Total Labour...	54 11			
		Total for 100 R. F. ...	111 5		Total for 100 R.F. ...	

CLXXIX.—Coping, Cutstone, semi-octagonal, 1st Sort. 9″ high and 1-6″ broad.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, rough ... C.F.	112	0 5½ foot	38 8			
Lime, slaked ... C.F	10	12 0 40 C. F.	3 0			
Sand ... ... C.F.	10	2 0 100 C. F.	0 3			
Charcoal ... ... lbs.	180	1 0 80 lbs.	2 4			
Iron ... ... lbs.	10	1 0 8 lbs.	1 4			
Sundries	...	.....	1 0			
		Total Materials.	46 3			
Labour.						
Masons for dressing ...	88	0 12 each.	66 0			
Do. setting ...	12	0 12 do.	9 0			
Nowgunnies	12	0 5 do.	3 12			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	¼	0 8 do.	0 2			
Smiths	4	0 12 do.	3 0			
Bellows-boys	4	0 4 do.	1 0			
Grinding chunam C.F.	10	4 0 100 C.F.	0 7			
Scaffolding	...	.....	1 0			
Sundries	...	.....	1 0			
		Total Labour...	86 7			
		Total for 100 R. F. ...	132 10		Total for 100 R. F.	

CLXXX.—Coping, Cutstone, semi-octagonal, 2nd Sort. 9″ high, 1-6″ broad.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.
		Rs. a. Per	Rs. a.		Rs. a. Per
Materials.					
Stones, rough ... C.F.	112	0 5½ foot	38 8		
Lime, slaked ... C.F.	12	12 0 40 C.F.	3 10		
Sand, fine ... ... C.F.	18	2 0 100 C.F.	0 6		
Charcoal ... ... lbs.	140	1 0 80 lbs.	1 12		
Iron... ... ... lbs.	8	1 0 8 lbs.	1 0		
Sundries	...	.....	1 0		
		Total Materials.	46 4		
Labour.					
Masons for dressing ...	58	0 12 each.	43 8		
Do. setting ...	10	0 12 do.	7 8		
Nowgunnies	12	0 5 do.	3 12		
Coolies	2	0 3 do.	0 6		
Women	6	0 2 do.	0 12		
Bhisties	½	0 8 do.	0 4		
Smiths	2½	0 12 do.	1 14		
Bellows-boys	2½	0 4 do.	0 10		
Grinding chunam C.F.	18	3 0 100 C.F.	0 9		
Scaffolding	...	.....	1 0		
Sundries...	...	.....	1 0		
		Total Labour...	61 3		
		Total for 100 R. F. ...	107 7		Total for 100 R. F.

CLXXXI.—Coping, Cutstone, semicircular, 1st Sort. 9″ high and 1-6″ broad.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Stones, rough ... C.F.	112	0	5	foot.	35	0						
Lime, slaked ... C.F.	10	12	0	40 C. F.	3	0						
Sand, fine ... C.F.	10	2	0	100 C. F.	0	3						
Charcoal ... lbs.	180	1	0	80 lbs.	2	4						
Iron ... ... lbs.	8	1	0	8 lbs.	1	0						
Sundries...	...	...		...	1	0						
		Total Materials.			42	7						
Labour.												
Masons for dressing ...	67	0	12	each.	50	4						
Do. setting ...	12	0	12	do.	9	0						
Nowgunnies	12	0	5	do.	3	12						
Coolies	2	0	3	do.	0	6						
Women	6	0	2	do.	0	12						
Bhisties	¼	0	8	do.	0	2						
Smiths	3	0	12	do.	2	4						
Bellows-boys	3	0	4	do.	0	12						
Grinding chunam. C.F.	10	4	0	100 C. F.	0	7						
Scaffolding	...	...		...	1	0						
Sundries	...	...		...	1	0						
		Total Labour...			69	11						
Total for 100 R. Ft. ...					112	2	Total for 100 R. F...					

CLXXXII.—Coping, Cutstone, semicircular, 2nd Sort. 9″ high and 1-6″ broad.

Artificers, Labourers and Materials for 100 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Stones, rough C.F.	112	0 5 foot.	35 0			
Lime, slaked C.F.	12	12 0 40 C.F.	3 10			
Sand ... C.F.	18	2 0 100 C.F.	0 6			
Charcoal ... lbs.	120	1 0 80 lbs.	1 8			
Iron ... lbs.	8	1 0 8 lbs.	1 0			
Sundries	...	.....	1 0			
		Total Materials.	42 8			
Labour.						
Masons for dressing ...	40	0 12 each.	30 0			
Do. setting ...	10	0 12 do.	7 8			
Nowgunnies	12	0 5 do.	3 12			
Coolies	2	0 3 do.	0 6			
Women	6	0 2 do.	0 12			
Bhisties	½	0 8 do.	0 4			
Smiths...	2	0 12 do.	1 8			
Bellows-boys	2	0 4 do.	0 8			
Grinding chunam C. F.	18	3 0 100 C. F.	0 9			
Scaffolding	...	.....	1 0			
Sundries	...	.....	1 0			
		Total Labour...	47 3			
Total for 100 R. Ft. ...			89 11	Total for 100 R. F...		

CLXXXIII.—Stone-steps.

Should be paid as Ashlar fine or rough or block in course as the case may be.

CLXXXIV.—Stone-stairs.

The cost depends very much on the length on the stone; only the part out of the wall should be paid for. The rate for dressing and setting per running foot will be somewhat as follows:—for steps of section shown in Plate XIX.

If the step is 5 feet out of the wall.

Artificers, Labourers and Materials for 5 Running Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Labour.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Masons, for dressing ...	5	0 12 each.	3 12			
Do. for setting ...	2	0 12 do.	1 8			
Nowgunnies ...	4	0 5 do.	1 4			
Women	1	0 2 do.	0 2			
Smiths	¼	0 12 do.	0 3			
Bellows-boys ...	¼	0 4 do.	0 1			
Centering	...	.....	0 8			
Sundries	...	.....	0 2			
		Total Labour ...	7 8			
Materials.						
Stone, rough ...	5	1 0 per R. F.	5 0			
Other materials, such as chunam, &c., say .	...	.....	2 8			
		Total Materials.	7 8			
		For 5 Running Feet ...	15 0		For 5 Running Feet.	
		or per Running Foot ...	3 0		or per Running Foot.	

CLXXXV.—Wooden Staircases.

For straight strings, take annas 12 for C. F. of teak for labour.

For curved strings, take three times the price of straight strings.

One inch planking for risers, allow annas 4 for labour.

One and a half inch planking for treads, allow annas 5 for labour, including nosings.

Wooden Balusters Re. 1 to Rs. 5 per R. F., according to design.

CLXXXVI.—Painting—3 Coats.

Artificers, Labourers and Materials for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Paint ... ... lbs.	8	16 0 Cwt.	1 2			
Linseed oil, boiled, pints.	3	2 8 gallon	0 15			
Spirits of turpentine ... ...pints.	1	3 0 do.	0 6			
Sundries	...	.....	0 5			
		Total Materials.	2 12			
Labour.						
Painters	1½	0 12 each.	1 2			
Coolies	1½	0 3 do.	0 5			
Women	2	0 2 do.	0 4			
Sundries	...	.....	0 3			
		Total Labour...	1 14			
Total for 100 Sq. Ft. ...			4 12	Total for 100 Sq. Ft.		

CLXXXVII—Varnishing—2 Coats.

Artificers, Labourers and Materials for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Varnish, Copal...pints.	3	6 0 gallon.	2 4			
Linseed oil, boiled.pints.	2	2 8 do.	0 10			
Sundries	...	.....	0 4			
		Total Materials.	3 2			
Labour.						
Painters	1½	0 12 each.	1 2			
Coolies	1½	0 3 do.	0 5			
Sundries	...	.....	0 3			
		Total Labour...	1 10			
		Total for 100 Supl. Ft. ...	4 12		Total for 100 Supl. Ft.	

CLXXXVIII.—White-washing—3 Coats.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime, fine ...lbs.	6	1 4 40 lbs.	0 3			
Rice ... ...lbs.	¼	0 1 lbs.	0 ¼			
Sundries, such as earthen pots, &c. ...	...	.....	0 ¼			
		Total Materials.	0 3½			
Labour.						
Bricklayers... ...	¼	0 10 each	0 2½			
Coolies	¼	0 3 do.	0 ¾			
Bhisties	⅛	0 8 do.	0 1			
Sundries	...	.....	0 ¼			
		Total Labour...	0 4½			
Total for 100 Supl. Ft., 3 coats ...			0 8	Total for 100 Supl. Ft. 3 coats		

N.B.—For repairs take ⅓ of this.

CLXXXIX.—Yellow Wash, No. 1.

Artificers, Labourers and Materials for 100 Superficial Eeet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Yellow earth, Mooltani. lbs.	5	0 8 40 lbs.	0 1			
Lime, fine ...lbs.	5	1 4 40 lbs.	0 2½			
Rice ... ...lbs.	¼	0 1 lbs.	0 ¼			
Sundries	...	.....	0 ¼			
		Total Materials.	0 4			
Labour.						
Same as for Whitewashing	...	.....	0 4½			
Total for 100 Supl. Ft. ...			0 8½	Total for 100 Supl. Ft.		

N.B.—For repairs take ⅔ of this.

CLXXXIX.—(*a*) Yellow Wash, No. 2.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Yellow ochre ...lbs.	½	0 4 lbs.	0 2			
Lime, fine ...lbs.	6	1 4 40 lbs.	0 3			
Rice ... ...lbs.	¼	0 1 lbs.	0 ¼			
Sundries	...	.....	0 ¼			
		Total Materials.	0 5½			
Labour.						
Same as for Whitewashing	...	.....	0 4½			
Total for 100 Supl. Ft. ...			0 10	Total for 100 Supl. Ft		

N.B.—For repairs take ⅔ of this.

CXC.—Blue Wash No. 1.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs a.
Cocoanut shells ...lbs.	3	0 8 40 lbs.	0 $\frac{1}{2}$			
Lime, fine ...lbs.	5	1 4 40 lbs.	0 $2\frac{1}{2}$			
Rice ... ...lbs.	$\frac{1}{4}$	0 1 lbs.	0 $\frac{1}{4}$			
Sundries	...	.....	0 $\frac{1}{4}$			
		Total Materials.	0 $3\frac{1}{2}$			
Labour.						
Same as for Whitewash.	...	.....	0 $4\frac{1}{2}$			
Total for 100 Supl. Ft. ...			0 8	Total for 100 Supl. Ft.		

N.B.—For repairs take $\frac{3}{8}$ of this.

CXC (*a*).—Blue Wash No. 2.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs a. Per	Rs. a.		Rs. a. Per	Rs. a.
Prussian Blue powder. lbs.	$\frac{1}{8}$	0 8 lbs.	0 1			
Lime, fine ...lbs.	6	1 4 40 lbs.	0 3			
Rice ... ...lbs.	$\frac{1}{4}$	0 1 lbs.	0 $\frac{1}{4}$			
Sundries	...	.....	0 $\frac{1}{4}$			
		Total Materials.	0 $4\frac{1}{2}$			
Labour.						
Same as for Whitewash.	...	.....	0 $4\frac{1}{2}$			
Total for 100 Supl. Ft. ...			0 9	Total for 100 Supl.Ft.		

N.B.—For repairs take $\frac{3}{8}$ of this.

CXCI.—Pink Wash.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Vermilion ... lbs.	$\frac{1}{8}$	4 0 lbs.	0 8			
Lime, fine ... lbs.	6	1 4 40 lbs.	0 3			
Sugar ... ... lbs.	$\frac{1}{4}$	0 4 lbs.	0 1			
Glue ... ... lbs.	$\frac{1}{16}$	0 8 lbs.	0 $\frac{1}{2}$			
Sundries ...	...	... ...	0 $\frac{1}{2}$			
		Total Materials.	0 13			
Labour.						
Same as for Whitewash	...	... ...	0 $4\frac{1}{2}$			
Total for 100 Supl. Ft...			1 $1\frac{1}{2}$	Total for 100 Supl. Ft.		

N.B.—For repairs take $\frac{2}{3}$ of this.

CXCII.—Green Wash.

Artificers, Labourers and Materials for 100 Superficial Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Green colour powder lbs.	2	0 8 lbs.	1 0			
Lime fine ... lbs.	5	1 4 40 lbs.	0 2½			
Sugar ... ... lbs.	¼	0 4 lbs.	0 1			
Glue ... ... lbs.	1/16	0 8 lbs.	0 ½			
Sundries ...	...	.....	0 ½			
		Total Materials.	1 4½			
Labour.						
Same as for Whitewash.	...	... ...	0 4½			
		Total for 100 Supl. Ft...	1 9		Total for 100 Supl. Ft.	

N. B.—For repairs take ⅔ of this.

CXCVI.—Galvanized Iron Wire Netting, ¾" Mesh.

Artificers, Labourers and Materials for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Wire netting, gal. iron S. Ft.	112	0 4 Supl. Ft.	28 0			
Teak for moulding or batten ... C.F.	½	3 0 C.F.	1 8			
Screws 1½" ...dozen.	10	0 3 dozen	1 14			
Sundries	...	... ...	0 4			
		Total Materials.	31 10			
Labour.						
Carpenters for moulding and fixing ...	4	0 12 each	3 0			
Coolies	2	0 3 do.	0 6			
Sundries	...	... ...	0 4			
		Total Labour...	3 10			
Total for 100 Supl. Feet of wire netting...			35 4	Total for 100 Supl. Ft. of wire netting.		

CXCVII.—Hoop Iron Trellis Work.

Materials and Labour for 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
*Hoop iron 1" 18 B.W.G. ... ... lbs.	128	9 8 Cwt.	10 14			
Nails 1½ inch ... lbs.	1½	0 3 lbs.	0 4			
Teakwood ... C.F.	...	3 0 C. F.	1 4			
Sundries	...	... ...	0 12			
		Total Materials.	13 2			
Labour.						
Blacksmith	½	0 12 each	0 6			
Carpenters	2	0 12 do.	1 8			
Coolies...	2	0 3 do.	0 6			
Sundries	...	... ...	0 4			
		Total Labour...	2 8			
		Total for 100 Square hoop iron trellis	15 10		Total for 100 Square hoop iron trellis ...	
		Add for painting both sides...	3 0		*Add* for painting both sides	
		Total Rs...	18 10		Total Rs. ...	

* *Note.*—The iron should be heated and rubbed over with boiled linseed oil before being worked up.

CXCVIII.—Teakwood Trellis Work.

Materials and Labour per 100 Square Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Battens 1″ × ½″ ...R F.	800	0 12 100 R. F.	6 0			
Nails ... ... lbs.	2	0 3 lbs.	0 6			
Teakwood ... C. F.	½	3 0 C. F.	1 8			
Sundries	...	.....	0 8			
		Total Materials.	8 6			
Labour.						
Carpenters ...	2	0 12 each.	1 8			
Coolies	2	0 3 do.	0 6			
Sawyers' work ... S.F.	20	0 12 100	0 3			
Sundries	...	.....	0 8			
		Total Labour...	2 9			
		Total for 100 Square Feet teak trellis	10 15		Total for 100 Sq. Ft. teak trellis ...	
		Add for painting both sides.	3 0		*Add* for painting both sides	
		Total Rs...	13 15		Total Rs...	

CXCIX.—Laying Cast Iron Pipes, 10″ diameter.

Materials and Labour per 100 R. F.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Tons. Cwt. qr. lbs.						
Pipes weighing 2 18 0 10 including carriage by rail, &c. &c. ...R. F.	100	130 0 Ton.	377 0			
Carting do. and hamalage ... ...Cwt.	58	0 2 Cwt.	7 4			
Joints of lead at 13 lbs. per joint ... No.	144 4/9	0 2 1/4 lb.	20 5			
Spun yarn ... lbs.	3	0 10 lb.	1 14			
Sundries, including wood, charcoal, &c...	...	.....	6 6			
		Total Materials.	412 13			
Labour.						
Excavation of trenches C. F.	900	0 12 100 C.F.	6 12			
Filling do. do. C. F.	900	0 6 do.	3 6			
Fitters ... ... No.	2 1/4	0 10 each	1 6			
Blacksmith and boy No.	1/2	0 12 do.	0 6			
Coolies ... ... No.	16	0 3 do.	3 0			
Women ... ... No.	3	0 2 do.	0 6			
Night watchman... No.	1	0 3 do.	0 3			
Making up gutters and damages	...	.....	1 9			
Sundries, including maistree, kárkuns, &c.	...	.....	3 0			
		Total Labour...	20 0			
Total cost of 100 R. F. of pipes laid complete			432 13			
		Or per Lineal foot Rs...	4 5			

CC.—Laying Cast Iron Pipes, 6" diameter.

Materials and Labour per 100 R. F.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Pipes weighing 1 ton 8 cwt., including carriage by rail, &c., &c. ... ...R. F.	100	125 0 Ton	175 0			
Carting do. and hamalage ... ...Cwt.	28	0 2 Cwt.	3 8			
Joints of lead at 6 lbs. per joint ... No.	66⅔	0 2¼ lb.	9 6			
Spun yarn ... Lbs.	2	0 10 lb.	1 4			
Sundries, including wood, charcoal, &c...	...	.....	3 10			
		Total Materials.	192 12			
Labour.						
Excavation of trenches ... ...C. F.	800	0 12 100 C.F.	6 0			
Filling do. do. ...C. F.	800	0 6 do.	3 0			
Fitters ... ... No.	2	0 10 each.	1 4			
Blacksmith and boy No.	½	0 12 do.	0 6			
Coolies ... ... No.	12	0 3 do.	2 4			
Women ... ... No.	2	0 2 do.	0 4			
Night watchman . No.	1	0 2 do.	0 2			
Making up gutters and damages	...	.....	1 4			
		Total Labour...	14 8			
Total cost of 100 R. F. of pipes laid complete			207 4			
Or per Lineal Foot, Rs. ...			2 1			

CCI.—Laying Cast Iron Pipes, 4″ diameter.

Materials and Labour per 100 R. F.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs a.		Rs. a. Per	Rs. a.
Materials.						
Pipes weighing 16 cwt. including carriage by rail, &c., &c. ...R. F.	100	125 0 Ton	100 0			
Carting do. and hamalage ... ... Cwt.	16	0 2 Cwt.	2 0			
Joints of lead at $3\frac{1}{2}$ lbs. per joint ... No.	$38\frac{8}{9}$	0 $2\frac{1}{4}$ lb.	5 8			
Spun yarn ... lbs.	$1\frac{1}{2}$	0 10 lb.	0 15			
Sundries, including wood, charcoal, &c...	...	.....	3 14			
		Total Materials.	112 5			
Labour.						
Excavation of trenches ... ...C. F.	700	0 12 100 C.F.	5 4			
Filling do. do. C. F.	700	0 6 do.	2 10			
Fitters ... ... No.	2	0 10 each	1 4			
Blacksmith and boy No.	$\frac{1}{3}$	0 12 do.	0 4			
Coolies ... ... No.	12	0 3 do.	2 4			
Women ... ... No.	2	0 2 do.	0 4			
Night watchman ...	...	.....	0 1			
Making up gutters and damages	...	.....	1 4			
		Total Labour...	13 3			
Total cost of 100 R. F. of pipes laid complete			125 8			
		Or per Lineal Foot, Rs...	1 4			

CCII.—Laying Cast Iron Pipes, 3″ diameter.

Materials and Labour per 100 R. F.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Pipes weighing 12 cwt., including carriage by rail, &c. ...R. F.	100	120 0 Ton	72 0			
Carting do. and hamalage ... ... Cwt.	12	0 2 Cwt.	1 8			
Joints of lead at 2½lbs. per joint ... No.	27⅞	0 2¼ lb.	3 14			
Spun yarn ... lbs.	1	0 10 lb.	0 10			
Sundries, including wood, charcoal, &c...	...	.....	2 4			
		Total Materials.	80 4			
Labour.						
Excavation of trenches ... ... C. F.	600	0 8 100 C. F.	3 0			
Filling do. do. C. F.	600	0 6 do.	2 4			
Fitters ... ... No.	1½	0 10 each	0 15			
Blacksmith and boy No.	¼	0 12 do.	0 3			
Coolies ... ... No.	8	0 3 do.	1 8			
Women ... ... No.	2	0 2 do.	0 4			
Night watchman ...	...	.....	0 1			
		Total Labour...	8 3			
Total cost of 100 R. F. of pipes laid complete			88 7			
		Or per Lineal Foot, Rs...	0 14			

CCIII.—Grinding Mortar.

Labour, and for preparing 100 Cubic Feet.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Pairs of bullocks ...	2	0 12 each pair	1 8			
Bhisties	1	0 8 each	0 8			
Coolies	2	0 3 do.	0 6			
Women	5	0 2 do.	0 10			
Total for preparing 100 C. F. of Mortar ...			3 0		Total for preparing 100 C. F. of Mortar.	

CCIV.—Tile-making—(Round).

Artificers, Labourers and Materials for 1,000.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Labour.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Moulder	1	0 8 each	0 8			
Coolies for earth and heaping tiles, &c. ...	2	0 3 do.	0 6			
Women for covering and cutting, &c. ...	2	0 2 do.	0 4			
Sundries, such as water, &c.	...	.....	0 1			
		Total Labour...	1 3			
Materials.						
Cart-loads of rubbish...	1½	0 8 each	0 12			
Sundries, fees, &c. ...	...	.....	0 1			
		Total Materials.	0 13			
Total for 1,000 Tiles ...			2 0		Total for 1,000 Tiles.	

CCV.—Brick-making on Tables.

Artificers, Labourers and Materials for 1,000 Bricks.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount	
Making Bricks.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Moulders	1	0	8	each	0	8						
Coolies for digging tempering, and conveying earth, &c. ...	3	0	4	do.	0	12						
Women and boys for conveying moulded bricks, and stacking dried ones	4	0	2	do.	0	8						
Pair of bullocks for water	$\frac{1}{8}$	1	0	pair	0	2						
Sundries, such as moulds, baskets, &c.	...	.....			0	2						
		Total Making Bricks ...			2	0						
Burning by Kiln.												
Coolies for loading kiln.	2	0	3	each	0	6						
Women do. ...	2	0	2	do.	0	4						
Firewood, dry, 28 maunds or ton ...	$\frac{1}{2}$	10	12	Ton	5	6						
Cooly for firing kiln ...	1	0	4	each	0	4						
Sundries	...	.....			0	4						
		Total Burning.			6	8						
Total for 1,000 Bricks ...					8	8	Total for 1,000 Bricks					

CCVI.—Brick-making on Ground.

Artificers, Labourers and Materials for 1,000 Bricks.	No. or quantity.	Rate.			Amount		No. or quantity.	Rate.			Amount
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs. a
Making Bricks.											
Moulders	1½	0	4	each	0	6					
Coolies for digging, tempering, and conveying earth ...	2	0	3	do.	0	6					
Women for turning and stacking dried bricks	2	0	2	do.	0	4					
Pair of bullocks for water	⅛		0	do.	0	2					
Sundries, such as moulds, &c.... ...	...		.....		0	1					
		Total Making Bricks ...			1	3					
Burning by Clamp.											
Coolies for loading clamp	2	0	3	each	0	6					
Women do. do. ...	2	0	2	do.	0	4					
Firewood, dry, 17½ maunds or ton ...	5/16	10	12	Ton	3	6					
Cowdung cakes, 6 doz.	500	0	3	100	0	15					
Rubbish—cart-loads ...	2	0	8	each	1	0					
Rice husk or brushwood cart-load	½	1	0	do.	0	8					
Sundries	...		.....		0	4					
		Total Burning.			6	11					
Total for 1,000 Bricks ...					7	14	Total for 1,000 Bricks				

CCVII.—Lime-burning with Charcoal.

Artificers, Labourers and Materials for 40 Cubic Feet Slaked Lime.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime-stone ... C. F.	30	10 0 100	3 0			
Charcoal ... lbs.	560	1 0 80 lbs.	7 0			
Ooplas (cowdung dried) No.	125	0 4 100	0 5			
Baskets ... No.	1	0 1 each	0 1			
Sundries	...	... ...	0 1			
		Total Materials.	10 7			
Labour.						
Lime-burner	½	0 8 each	0 4			
Coolies for breaking and loading, &c. ...	5	0 3 do.	0 15			
Women do. ...	4	0 2 do.	0 8			
Bhisties	¼	0 8 do.	0 2			
		Total Labour...	1 13			
Total for 1 candy or 40 C.F. of slaked lime sifted			12 4		Total for 1 candy or 40 C. F. of slaked lime sifted.	

N.B.—Unslaked stone-lime increases 1½ times in bulk when slaked, and yields 1½ times in bulk of pure lime.

CCVIII.—Lime-burning with Firewood.

Artificers, Labourers and Material for 40 Cubic Feet Slaked Lime sifted.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Lime kunker, 91 maunds ...or C. F.	45	9 0 100 C.F.	4 1			
Firewood, dry ...Tons	½	10 12 Ton	5 6			
Cowdung cakes ...No.	125	0 4 100	0 5			
Baskets... ... No.	1	0 1 each	0 1			
Sundries	...	... ...	0 1			
		Total Materials.	9 14			
Labour.						
Same as above ...	...	... ...	1 13			
Cooly, extra, for cutting wood	1	0 4 each	0 4			
		Total Labour...	2 1			
Total for 1 candy or 40 C. F. of slaked lime sifted			11 15		Total for 1 candy or 40 C. F. of slaked lime sifted.	

One C. F. of lime kunker weighs 81 lbs.
One C. F. of unslaked kunker lime weighs 63·5 lbs.
Unslaked lime increases 1·23 times in bulk when slaked, and yields ·90 times in bulk of pure lime.
One C. F. of slaked kunker lime weighs 65·5 lbs.

CCIX.—Lime-burning with English Coal.

Materials and Labour.	No. or quantity.	Rate.			Amount.		No. or quantity.	Rate.			Amount.
Materials.		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs. a.
Broken kunker ...C.F.	435	7	0	100	30	7					
* English coal ...Tons	2¼	22	0	Ton	49	8					
Carting coal to kiln ... ...Tons	2¼	1	0	do.	2	4					
Babool firewood ...Mds.	11	10	0	Khandi	5	8					
Cowdung cakes ... No.	300	4	0	1,000	1	3					
Sundries	...	...		...	1	8					
		Total Materials.			90	6					
Labour.											
Lime-burners ...No.	8	0	4	each	2	0					
Watchmen ...No.	8	0	3	do.	1	8					
Loading and unloading coolies...No.	12	0	3	do.	2	4					
Do. do. women ... ...No.	4	0	2	do.	0	3					
Preparing lime, coolies ... ...No.	18	0	3	do.	3	6					
Do. do. women ... ...No.	18	0	2	do.	2	4					
Bhisties ... ...No.	6	0	8	do.	3	0					
Sundries	...	...		...	1	0					
		Total Labour ...			15	14					
Total for 435 C.F. ...	...	...		...	106	4					
Or for 1 candy or 40 C.F. of slaked lime ...					9	12					

Note.—This rate would admit of much reduction if the quantity of lime required were large, and continuous burning kilns were used. If burnt in smaller quantities than the above, the rate is a little higher.

* Price at Poona Railway Station.

CCX.—Wire Fencing.

Materials and Labour.	No. or quantity.	Rate.			Amount.		No. or quantity.	Rate.			Amount	
		Rs.	a.	Per	Rs.	a.		Rs.	a.	Per	Rs.	a.
Materials.												
C. I. Screw bases 3'	No. 576	0	13½	each	486	0						
W. I. intermediate standards ...	No. 576	0	8¼	do.	297	0						
C. I. straining posts	No. 10	6	6	do.	63	12						
Twisted wire ...	Tons 2 1/10	11	0	cwt.	445	8						
G. I. straining bolts	No. 100	0	4½	each	28	2						
Fluted keys ...	lbs. 45½	18	0	cwt.	7	5						
W. I. wedges ...	No. 576	0	½	each	18	0						
Sundries	...	...		...	15	0						
		Total Materials.			1,360	11						
Labour.												
Coolies: excavating holes for screw bases.	No. 109	0	3	each	20	7						
Do. distributing and fixing screw bases, standards and straining wire	No. 155	0	3	do.	29	1						
Muccadums ...	No. 64	0	6	do.	24	0						
Sundries	...	...		...	5	0						
		Total Labour ...			78	8						
Total cost per mile in Bombay ...					1,439	3						

Note.— Weight of Iron Work per mile.

Nos.		Tons.
576	C. I. screw bases	7·50
576	W. I. intermediate standards	3·40
10	C. I. straining posts	0·93
20	Bundles twisted wire	2·02
100	G. I. straining bolts	0·10
2,880	Fluted keys	0·01
576	W. I. wedges	0·12
	Total ...	14·08

Cost of carriage by rail 14½ pies per ton per mile.

CCXI.—Laterite and Lime (Foundation).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stones 30″ × 10″ × 8″ squared and delivered at site. No.	72	15 0 100 No.	10 13			
Lime ... ...C.F.	12	12 0 40 C.F.	3 10			
Sand ... ...C.F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	15 9			
Labour.						
Masons for setting. No.	5	0 10 each.	3 2			
Coolies ... ... No.	6	0 3 do.	1 2			
Women ... ... No.	5	0 2 do.	0 10			
Grinding chunam. C.F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Sundries	...	.....	0 12			
		Total Labour ...	6 7			
		Total for 100 C. F. ...	22 0			

	Rs.	a.
Note.—Cost of stone at quarry	5	12
,, ,, dressing do.	4	12
,, ,, conveyance 3 miles	4	8
Cost of 100 stones squared and delivered ...	15	0

CCXII.—Laterite and Lime (Plinth).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stones 24″ × 12″ × 8″ squared and delivered at site No.	75	16 0 100 No.	12 0			
Lime ... ...C.F.	12	12 0 40 C.F.	3 10			
Sand ... ...C.F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials .	16 12			
Labour.						
Masons for setting. No.	6	0 10 each.	3 12			
Coolies ... ... No.	5	0 3 do.	0 15			
Women ... ... No.	4	0 2 do.	0 8			
Grinding chunam. C.F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Sundries	...	.....	0 12			
		Total Labour ...	6 12			
Total for 100 Cubic Feet ...			23 8			

Note.—

	Rs. a.
Cost of stone at quarry	5 12
„ „ dressing do.	5 12
„ „ conveyance 3 miles	4 8
Cost of 100 stones squared and delivered ...	16 0

CCXIII.—Laterite Superstructure (Block in course).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stones 18″ × 9″ × 8″ squared and delivered at site. No.	134	9 0 100 No.	12 1			
Lime ... ... C.F.	12	12 0 40 C.F.	3 10			
Sand ... ... C.F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	16 13			
Labour.						
Masons for setting. No.	6	0 10 each.	3 12			
Coolies ... ... No.	6	0 3 do.	1 2			
Women ... ... No.	4	0 2 do.	0 8			
Grinding Chunam. C.F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 12			
		Total Labour...	7 15			
		Total for 100 C.F. ...	24 12			

	Rs.	a.
Note.—Cost of stone at quarry	3	10
,, ,, dressing do.	3	2
,, ,, conveyance 3 miles	2	4
Cost of 100 stones squared and delivered...	9	0

CCXIV.—Laterite Arching over Doors and Windows.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stones rough 18″ × 18″ × 7″ delivered at site ... No.	100	10 0 100 No.	10 0			
Lime ... ... C.F.	12	12 0 40 C.F.	3 10			
Sand ... ... C.F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	14 12			
Labour.						
Masons for dressing ... ... No.	16	0 10 each.	10 0			
Do. setting. No.	6	0 10 do.	3 12			
Coolies ... ... No.	6	0 3 do.	1 2			
Women ... ... No.	4	0 2 do.	0 8			
Bhisties ... ... No.	½	0 8 do.	0 4			
Carpenter ... No.	½	0 12 do.	0 6			
Grinding chunam. C.F.	18	3 0 100 C.F.	0 9			
Scaffolding	...	.....	1 0			
Sundries	...	.....	0 12			
		Total Labour...	18 5			
		Total for 100 C. F. ...	33 1			

CCXV.—Laterite Paving.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stone dressed and delivered 12″ × 12″ × 8″ ... No.	100	8 0 100 No.	8 0			
Lime ... ...C. F.	12	12 0 40 C. F.	3 10			
Sand ... ...C F.	18	2 0 100 C. F.	0 6			
Sundries	...	.....	0 6			
		Total Materials.	12 6			
Labour.						
Masons for setting No.	8	0 10 each.	5 0			
Coolies ... ... No.	5	0 3 do.	0 15			
Women ... ... No.	5	0 2 do.	0 10			
Grinding chunam. C. F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Sundries	...	.....	0 6			
		Total Labour...	7 12			
Total for 100 Superficial Feet ...			20 2			

CCXVI.—Laterite Cornice 8″ high.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a		Rs. a. Per	Rs. a.
Materials.						
Laterite stones 21″ × 12″ × 8″ delivered at site ... ... No.	200	6 4 100 No.	7 8			
Lime ... ...C. F.	12	12 0 40 C.F.	3 10			
Sand ... ...C. F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	12 4			
Labour.						
Masons for dressing No.	10	0 10 each.	6 4			
Masons for setting No.	6	0 10 do.	3 12			
Coolies ... ... No.	6	0 3 do.	1 2			
Women ... ... No.	4	0 2 do.	0 8			
Grinding chunam. C. F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Sundries	...	.....	0 12			
		Total Labour...	13 3			
		Total for 100 R. F. ...	25 7			

CCXVII.—Laterite Coping, semioctagonal top, 8″ high.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Materials.						
Laterite stones, rough 15″ × 18″ × 8″ delivered at site ... No.	100	6 0 100 No.	6 0			
Lime ... ...C. F.	12	12 0 40 C.F.	3 10			
Sand ... ...C. F.	18	2 0 100 C.F.	0 6			
Sundries	...	.....	0 12			
		Total Materials.	10 12			
Labour.						
Masons for dressing ... ... No.	12	0 10 each.	7 8			
Masons for setting ... ... No.	6	0 10 do.	3 12			
Coolies ... ... No.	6	0 3 do.	1 2			
Women ... ... No.	4	0 2 do.	0 8			
Grinding chunam. C.F.	18	3 0 100 C.F.	0 9			
Bhisties ... ... No.	½	0 8 each.	0 4			
Sundries	...	.....	0 12			
		Total Labour...	14 7			
		Total for 100 R. F. ...	25 3			

CCXVIII.—Laterite Concrete.

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity.	Rate.	Amount
Materials.		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Laterite stone metal at site (size 2″). ...C. F.	78	2 8 100 C.F.	2 0			
Lime, slaked ...C. F.	26	12 0 40 C.F.	7 13			
Sand ... ...C.F.	52	2 0 100 C.F.	1 0			
Sundries	...	.....	0 3			
		Total Materials.	11 0			
Labour.						
Grinding chunam C. F.	52	3 0 100 C.F.	1 9			
Coolies ... No.	4	0 3 each.	0 12			
Bhisties ... No.	½	0 8 do.	0 4			
Sundries	...	.....	0 3			
		Total Labour...	2 12			
Total for 100 C. F. ...			13 12			

CCXIX.—Laterite Metal from Boulders.

(Size 2½″).

Materials and Labour.	No. or quantity.	Rate.	Amount	No. or quantity	Rate.	Amount
		Rs. a. Per	Rs. a.		Rs. a. Per	Rs. a.
Labour.						
Coolies for quarrying ... ... No.	2	0 3 each	0 6			
Hammerman ... No.	1	0 6 do.	0 6			
Women for breaking ... ... No.	5	0 2 do.	0 10			
Sundries	...	.....	0 2			
Total for quarrying and breaking 100 C. F.			1 8			

X.—NOTES.

	Page
Stone	287
Brick-work	288
Plaster, Cements, &c.	290
Wood Work	300
Teak Trusses	303
Iron do.	303
Paints. Washes, Varnishes, &c.	306
Lightning Conductors	310
Management of Portable Engines	312
Bridges	318
Pile Driving	319
Pipe Laying	320
Pumping	322
Boring	322
Knotting and Splicing	324
Concrete Arched Roofing	329
Instructions for using Dynamite	333
Sanitation of working Parties	337
Miscellaneous Notes	340

X.—NOTES.

Stone.

The principal stones used for building purposes in the Bombay Presidency are :—

Blue Basalt or Trap.—This varies much in quality. The best quality is hard, of a bright colour, breaking with a clean fracture, and ringing when struck with a hammer, well suited for paving and metalling roads. Weight per cubic foot being 187·5 lbs.

Bombay Basalt, which is very hard and good, gives a resistance to crushing of 12,548 lbs. per square inch.

Inferior qualities are often much softer and easier to work, but in a few years become discoloured, and decay rapidly. When stone from boulders is used, great care should be taken not to admit stones that peel, as some stone of this class, though perfectly sound to look at, peels like an onion after a few months' exposure to the weather.

Yellow Basalt.—Obtained at Kúrla on the G. I. P. Railway; resistance to crushing, 12,219 lbs. per square inch.

Red Basalt.—From Satry or from near Talegaon in the Poona Districts.

Hemnuggur.—Obtained about 40 miles from Ahmedabad. A moderately hard, fine-grained silicious sandstone. Resistance to crushing, 5,125 lbs. per square inch.

Porebunder.—A calcareous grit, composed of formaniferous shells and a few grains of quartz, joined by solution of shells and re-crystallization. Good Porebunder stone should be of fine grain, good colour, and free from salt, with no black specks in it; and if it has been at any time saturated with sea water, it should be rejected. Great care should be taken to lay it on its natural bed in the work. Resistance to crushing, 2,451 lbs. per square inch.

Granite.—Excellent granite is obtainable in Kánara, but it is difficult and expensive to work.

Laterite.—A clay-stone impregnated with iron in the form of red and yellow ochres, with a perforated and cellular structure, is obtained in Belgaum, Ratnágiri, Kánara, Dhárwár, and Mahábaleshvar. It is very easy to work, but care is required in selection of stone, as the inferior sorts decay rapidly when exposed to the weather.

Limestone.—A splendid limestone obtained in layers from 3 inches to 15 inches in thickness is found at Sháhábad on the G. I. P. Railway, but the expense of carriage by rail almost precludes its use.

Sandstone, sienite, slate, and ironstone are met with in the Southern Marátta Country.

Brickwork.

Colouring by dipping.—Bricks or tiles coloured in this way are said to stand any amount of exposure to the weather without losing their colour, and the surface of such a brick will never take on any vegetable matter when exposed to a damp atmosphere. The materials used for the colouring liquid are turpentine, linseed-oil, and litharge, with colouring matter as may be required.

An earthenware box is provided, a few inches larger each way than a common brick, and it is half filled with liquid of about the consistency of thick cream. The bricks to be coloured are laid upon an iron plate with a fire underneath, and heated, not to a great heat, but too great to admit of their being handled. They are then taken one at a time and dipped into the liquid for a few seconds, then placed on a table to dry, which they do in a few minutes. They are then taken and slightly washed in cold water, and placed aside to dry. In open and porous bricks the colouring matter will penetrate about ⅛ of an inch. The following are the proportions used for some of the colours :—

I.—For Dark Red Bricks.

1½ pints of turpentine.
1½ „ linseed-oil.
¼ lb. of litharge.
½ oz. of Indian red.
Mix well together and use as above.

II.—For Blue Bricks.

1 pint of turpentine.
1 „ linseed-oil.
½ oz. of litharge.
1 lb. of French ultramarine.

III.—For Black Bricks.

2 ozs. of litharge.
6 „ manganese.
4 „ linseed-oil, boiled.
6 „ turpentine.

IV.—For Grey Bricks.

3 ozs. of white lead.
1 oz. of litharge.
1 „ manganese.
2 ozs. of boiled linseed-oil.
4 „ turpentine.

These colours may also be applied to walls already built. In such a case the bricks are carefully cleaned, and the liquid heated and laid on with a brush.

Terra Cotta.—This material is now much used in England for frieze in cornice, mouldings, panels, &c., and might be introduced more frequently into buildings in this country with great advantage.

It could probably be delivered in Bombay, at about the following prices including packing*:—

Round columns in 18-inch lengths, 12-inch diameter with base caps to drawings included, complete, net per foot running	Pilasters in 18-inch lengths 12 × 12 inch with base and cap complete, net per foot running.	Other Terra Cotta goods not more than 1 foot cubic, or 18 inches long.
Plain at 5*s.*, fluted or ribbed 5/6, moulded, twisted, foliated, or otherwise ornamented 6/6.	Plain 5/6, moulded or panelled 6/, panelled or otherwise ornamented 7/.	Net per cubic foot ordinary pattern 5*s.*, extra or ornamented patterns, or larger sizes not being more than 24 feet long, from 6*s.* to 7/6 per cubic foot.

All columns and pilasters would be rebated, fitted, and numbered and all other goods would also be fitted and numbered, so that they could readily be fixed without skilled labour.

Hollow Walls.—Examples of these made with ordinary bricks are given on the plates on brickwork. The advantages of this method of construction are economy, lightness, freedom from damp, and, in this country, probably coolness.

Brick Nogging and Teak Posts.—This is an excellent, cheap, and very desirable mode of construction, and might be frequently adopted for civil buildings in the mofussil with great advantage. A fair estimate for single-storied buildings of this class finished complete in Bombay is from Rs. 3 to 4 per superficial foot of ground covered. (See Specification No. L.)

Tiled Walls.—A very good method of protecting brick or other walls much exposed to rain, is by nailing battens to the wall, and on to these fixing small flat tiles, either square or fancy shaped, fixed in the same manner as slates. In the south of England houses are often built in this manner, the roof, &c., being supported on wooden posts, to which the exterior battens carrying the tiles are fixed, a space being left between them and the interior battens to which the plaster is applied. The effect is neat and picturesque, and cost very moderate.

Laying Bricks.—In foundations and other walls where joints are left rough, an English bricklayer can lay 1,500 to 1,600 bricks in 10 hours; but where facework has to be worked fair, not more than 1,000; and in walls carefully jointed and faced with picked bricks, not more than 500, provided it is straight walling without many openings.

* From Messrs. Gibbs and Canning, Tamworth.

Plasters, Cements, &c.

Madras Plaster.—From Specification by Colonel Fuller, R.E. The finishing coats to be as follows :—

Two coats, of a mixture of powdered China 2 parts, powdered marble 1 part, and fine lime to be laid on and rubbed into the plaster, each coat for 2 consecutive days. The China and marble powders to be freed from dust, which is to be reserved for after-coatings.

Two coats, of China powder 1 part, and marble 2 parts, as above, each coat being well rubbed in for one day.

Two coats of "Turree" finely shifted shell lime to be laid on and well rubbed until the required polish is obtained. A small quantity of gum or white of egg to be used in the last 2 coats.

Mogul Mortar.—(Khándesh).

To 1 pucka khandi fine chunam (80 C. F.)

add 10 C. F. Sand.
12 lbs. Jagree.
8 „ Heerda.
8 „ Googul.
6 „ Caoutchouc.
10 „ Hemp.
6 „ Gum.

Oil Cement.—For laying earthenware pipes,

5 lbs. dry slaked lime,
1 lb. oil by weight,

pounded in stone mortar with iron pestle, for 6 hours, to reduce it to a thick paste for use.

Durable Cement.—For steam and water joints. Take 10 lbs. of ground litharge, 4 lbs. ground Paris white, ½ lb. yellow ochre, 2 lbs. red lead, ½ oz. of hemp, cut into ½ inch lengths. Mix all together into boiled linseed-oil to the consistency of very stiff putty. Make the joint in the usual way.

Useful Cement.—For reservoirs, cisterns, &c. Take 90 parts of well-burnt brick (fire-brick is best), 10 parts of litharge, well pulverised and mixed together to consistency of plaster, with boiled linseed-oil. Use in same way as plaster, previously wetting the parts to be covered with water. In 3 or 4 days the cement will become hard.

Waterproof Mastic Cement.—Molesworth.

1 red lead,
4 ground lime,
5 sharp sand, mixed with boiled oil,
or 1 red lead,
5 whiting,
10 sharp sand, mixed with boiled oil.

Rust Joint Cement.—(Quickly setting).

1 sal ammoniac in powder (by weight),
2 flower of sulphur,
80 iron borings,

made to a paste with water.

Rust Joint.—(Slowly setting).

2 sal ammoniac,
1 flower of sulphur,
200 iron borings.

The latter cement is the best if the joint is not required for immediate use.

Red Lead Cement.—(For face joints).

1 oz. white lead,
1 „ red lead,

mixed with linseed oil to the proper consistency.

Glue.—To resist moisture 1 lb. glue melted in 2 quarts of skimmed milk. When strong glue is required, add powdered chalk to common glue.

Marine Glue.—1 of India rubber, 12 mineral naptha or coal tar; heat gently, mix, and add 20 of powdered shellac. Pour out on a slab to cool; when used to be heated to about 250°.

Quick Drying Glues.—1*st.* Break up the glue, dissolve in common whisky or spirit of any sort without heat. Cork tight. It will keep for years.

2*nd.*—Shellac dissolved in methylated spirits, or French glue in acetic aid.

Glue Cements—(to resist moisture.)

1*st.*—1 glue.
1 black rosin.
¼ red ochre.
} Mixed with the least possible quantity of water.

2*nd.*—4 of glue.
1 of boiled oil by weight.
1 oxide of iron.

Liquid Glue.—Mix 4 parts of treacle with 12 parts of water by weight, and add 1 part of quick lime; heat to about 150° Fah. and afterwards macerate for two or three days with frequent agitation. Decant from the undissolved lime, the solution having the consistency of mucilage. Add to the solution ¼th of its weight of glue and 3 per cent. of glycerine. This makes a good strong liquid glue.

To fill Cracks in Terraced Roofs—

2 parts linseed-oil (raw),
2 „ rosin,
1 „ pumice if obtainable; if not, use fine sand.

Boil oil, pound pumice and mix with pounded rosin; put in these whilst hot, and mix till a stick will almost stand upright. (Add rosin if above is not sufficient.) The cracks should not be disturbed or dug out with a trowel, but the liquid mixture poured in and surface smoothed over.

To stop Leakage in Aqueducts.—The Executive Engineer for Irrigation, Poona, states that 2 coats of oxide of iron paint on top of the plastered arches on the Mutha Canal stopped their leaking.

Dr. O'Shaughnessy's Cement.—The composition used in this country for the protection of telegraph wires laid underground, consists of 120 parts (by weight) of pure resin (American) and 300 sand; it has been recommended for the lining of cisterns and other building purposes, and the following is Dr. O'Shaughnessy's description of the manner of using it for coating floors, cisterns, &c.:—

The resin is melted in an iron vessel, the sand stirred in and well incorporated with an iron stirrer, and the whole poured when of the consistence of treacle. Great care must be taken to prevent the resin from taking fire, or charring, by too prolonged or too high a heat.

The cement thus prepared may be cast into bricks or tiles, or poured on floors or roofs or on planked flooring, to all of which it firmly adheres. Joints are readily and securely made by pouring a little melted resin or pitch into the line of juxtaposition of the bricks or tiles, and cracks are filled up in the same simple way.

A tile of this kind 12 inches square and 1½ inches thick weighs 387 tolas. If carefully prepared, this cement is totally impermeable to water, and is not affected by the fiercest solar heat. It withstands dead pressure better than common bricks or tiles.

The composition is brittle, so that for roofing or flooring purposes it is very much improved by slips of bamboo being inserted in it while soft. A very coarse Durmah mat placed on its surface while still soft is a great improvement to it for flooring purposes, and if used in a thoroughfare, a thin layer of sand or road dust laid over it while hot will be found to preserve the surface from abrasion. It need scarcely be pointed out, that notwithstanding the unquestionable and remarkable advantages derivable from the use of this cement, it is open to the very serious objection of being dangerous in cases of fire.

Concrete for Sea Works.—Concrete has been largely used in the form of blocks in the superstructure of the Manora Breakwater, Karáchi Harbour Works. The size of the blocks was 16 cubic yards, weighing 27 tons each, and the composition as follows:—

	Cubic Feet.
Portland Cement	44*
River sand	180
Shingle	252
Quarry lumps, conglomerate, 14 to 28 lbs. each...	144
Salt water (liable to slight variation according to weather)	432 gallons.

The above refers to the heavy cement, which weighed in England 118 to 120 lbs. to the bushel.

* Indian bulk; see Roorkee Professional Papers, No. LXXXVIII, 2nd Series.

When lighter cements were used, the allowance was proportionately increased.

Full details of the process and cost will be found in No. CXXXIV of the Roorkee Professional Papers on Indian Engineering (2nd Series) for November 1874.

Artificial Hydraulic Lime.—Large quantities of artificial hydraulic lime have been successfully used on the Karáchi Harbour Works and on irrigation works in Sind.

In the manufacture 5½ parts by measure of ordinary slaked lime is mixed intimately (with the help of fresh water) with 1 part of clay.

The mixture is made into balls which, when thoroughly dried in the sun, are burned in a kiln. One part of this lime takes two of sand for superstructure work, and 3 for mortar in concrete, and footings.

Full description and details of the process and cost will be found in No. CXLVI. of the Roorkee Professional Papers on Indian Engineering, 1st Series, for May 1867; also in the Roorkee Manual of "Limes, Mortars, and Cements", pages 21 and 26 (4th edition).

Portland Cement*.—The strength of cement decreases rapidly with the proportion of sand mixed with it. From experiments it was found that bars 1½ inches square of cement 112 lbs. to the bushel will break at the following weights in lbs.:—

Gauged after	Neat cement.	1 sand 1 cement.	2 sand 1 cement.	3 sand 1 cement.	4 sand 1 cement.	5 sand 1 cement.
1 month.	680	309	123	58	32	21
3 months	878	367	254	135	109	88
6 „	979	547	425	232	157	95
12 „	1,076	700	458	320	221	122

Setting in water.—Cement increases in strength by setting in water.

	Average strength.	At end of 12 months.
In water	100 ...	1,099
Out of water in-doors.	81 ...	827
Outof water exposed.	77 ...	720

Weight.—Cement increasses in strength according to its weight.

Weight per bushel.	Tensile strain on 2·25 square inches
106 lbs.	472
110 „	708
120 „	732
130 „	914

From which it would appear that an increase in weight of 24 lbs. to the bushel nearly doubles the tensile breaking weight of the cement.

Salt Water.—Cement appears to gain strength if mixed with salt water instead of fresh.

Cement 121 lbs. to the bushel.

After.	Fresh water.	Salt water.
7 days ...	922 lbs. ...	943 lbs.
1 month ...	1,123 „ ...	1,203 „
2 months ...	1,175 „ ...	1,341 „
4 „ ...	1,320 „ ...	1,464 „
5 „ ...	1,327 „ ...	1,353 „

* From "The Manufacture of Portland Cement, by H. Reid, 1868."

Compression.—Some experiments on compression of P. C. Bricks $9'' \times 4{\cdot}25'' \times 2{\cdot}75'' = 106{\cdot}18$ c. in. The surface subjected to pressure being $9'' \times 4{\cdot}25'' = 38{\cdot}25$ square inches, gave the following results :—

	3 months.		6 months.		9 months.
Neat P. C.	65 tons	...	92	...	102
1 cement 1 sand.	43 „	...	59	...	78
1 „ 2 „	34 „	...	47	...	62
1 „ 3 „	24 „	...	37	...	41
1 „ 4 „	23 „	...	31	...	38
1 „ 5 „	16 „	...	26	...	29

Cement.—The quay walls at Dublin were built of concrete 1 P. C. to 10 Liffy gravel, and stood after three months a crushing power of 16 tons per square foot.

Sand.—Sand to be the most useful in a cement mortar should have porosity enough to fully absorb the moisture from the cement.

Paving.—Portland Cement in combination with chippings from Bath stone was tried some years ago, and paving slabs thus made are stated to have stood the traffic on the footpath of King William Street in the City for 14 years. The best cement, weighing 140 lb. to the bushel, was used mixed with the smallest possible quantity of water poured through the fine rose of a water-pot. The mixture of cement and chippings was shovelled into cast-iron moulds, bolted firmly together and materials rammed with iron rammers.

Portland Cement Skin over Concrete.—Useful for floors of all sorts. Very durable and much cheaper than paving. It can be made rough or smooth, even finely polished if necessary. Lay ordinary concrete, but with small sized metal or gravel, in the usual way to $\frac{1}{4}''$ under required level, only being *very* careful to thoroughly consolidate by ramming. Let some time, say one month, elapse before laying on the cement skin, so that the concrete may have taken its final set before it is covered, otherwise it may cause cracks in the skin; then clean and scrape away all superfluous mortar and wet the surface; cement and clean sand to be mixed in equal proportions and floated on rapidly, average $\frac{1}{2}''$ thickness is ample; water to be sparingly used in mixing, excess of it to be avoided. Keep covered with wet grass for ten days.

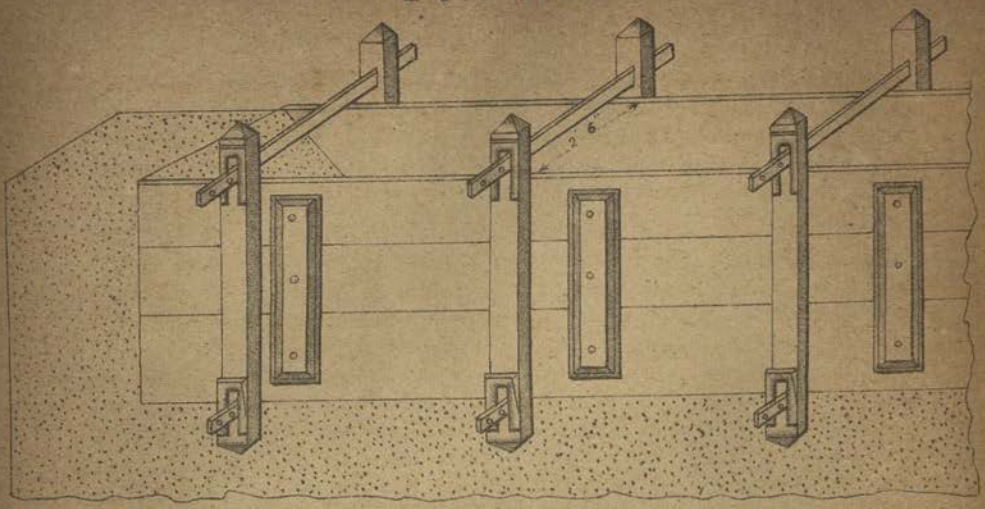
Wrought-iron.—If wrought-iron is roughed, it will form a perfect connection with Portland Cement coating.

Affinity for water.—Good cement requires but little water to make good mortar. For 100 volumes of cement 44 volumes of water are generally added. If mixture requires more, heat will be developed, showing that the cement contains free or caustic lime. If less, it is a sign that it has been over-burnt, is too old, or is already charged with water or carbonic acid.

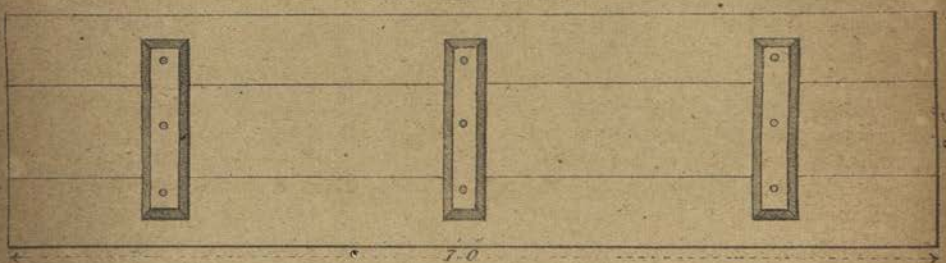
Professor J. Manger says good cement mortars require—

Cement.		Sand.		Water.		Mortar.
1	to	0	require	·44	and yield	·91
1	„	1	„	·66	„	1·83
1	„	2	„	·88	„	2·87
1	„	3	„	1·20	„	3·80
1	„	4	„	1·65	„	5·01

Pise Box

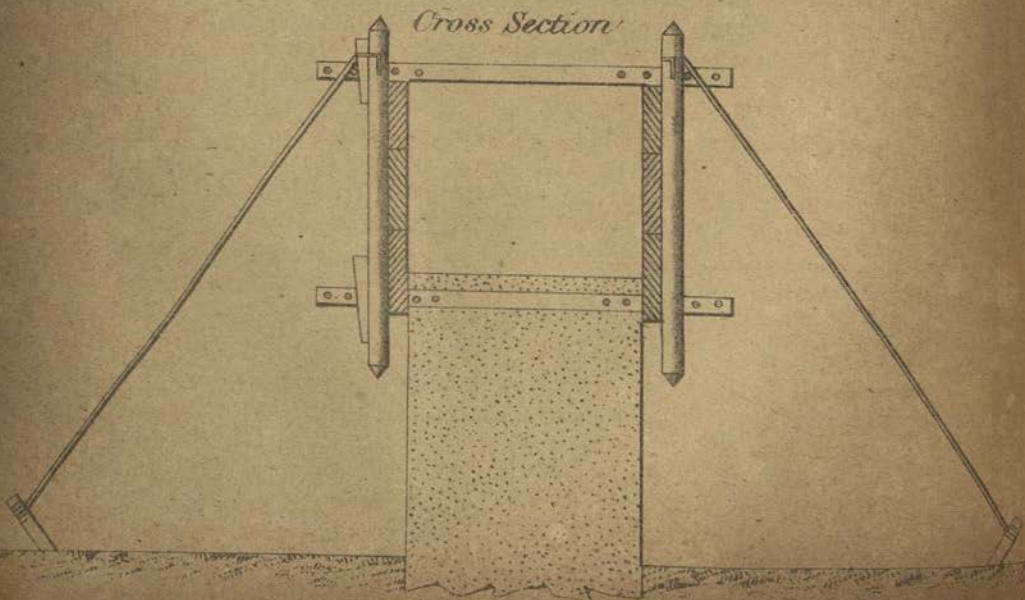


Side Elevation



Side Elevation of Pise Box.

Cross Section



Bricks.—An excellent flooring brick or tile can be made from ground clinkers, vitrified bricks, and such materials mixed with a portion of good cement. The clinkers, &c., are roughly ground, and when well mixed with the cement, the materials are moulded and left to set. Bricks of this kind are very hard and heavy and wear remarkably well under heavy traffic.

Pisé Work.—The following is a description of the Pisé work executed at Etah Jail during 1867-68.* From the accompanying sketch (see Plate XX) of the boxes used, it will be seen that the method adopted is equally applicable for concrete work.

The boxes in which the Pisé work was executed consisted of 2 wooden frames 10′ long and 2½′ broad, made of planks nailed on to stout battens. They are held together by 4 pairs of posts 3″ × 3″ which are connected above and below with tie bars of flat iron 1½″ × ¼″. The two bars have at each end a certain number of ½″ holes punched in them to receive pins for preventing the posts from slipping off. By changing the pins, walls of any dimensions can be obtained. Wedges of hard wood with longitudinal slots are introduced between the posts and the pins to adjust the breadth of the boxes to the standard gauge. After the boxes are fixed and adjusted they are secured in position by ropes passing over them and tied to stakes on each side. Any deflection from the vertical should be corrected at the commencement of the work, as it is impossible to alter the position of a box after it is half full. Any earth which is suitable for brick-making will do for Pisé work. On being dug out it is passed through a screen with ½″ meshes and thrown into the boxes in even layers of 6″ in depth.

Generally fresh earth contains sufficient moisture to ensure consolidation, but if it is found that it jumps up under the rammers, it should, on being thrown into the boxes, be sprinkled with a little water out of a tin can with a rose. The watering should be as uniform as possible, as if it is applied unequally, it will liquify the earth, which will commence oozing out under the rammers. Pisé work executed with too much water is worse than if done with dry earth, as, on account of the elasticity of the wet earth, the effect of the ramming is deadened and the earth remains unconsolidated. The men should be prohibited from keeping time in ramming, as it causes vibration, which is injurious to the stability of the wall.

On working over an old course it is as well to set the lower tie bars about 4 inches into the same to give the boxes a firm hold on the old work. Thereby the joints become imperceptible, and the upper edge of the lower course is prevented from chipping off.

The implements used are 3 rammers of different shapes. The earth is first beaten down with a V-shaped rammer, and then surfaced with a flat-bottomed one. The sides are consolidated with a spade-shaped one.

---

* From Standard Specifications for Oudh.

To overcome the difficulty experienced in extracting the lower tie bars, holes were made in the latter 3″ apart throughout their whole length. A pin was inserted against which a crowbar with a long slot, and well bent at the end, was made to work. An equal pressure could thereby be exerted against the tie bars, which can thus be extracted with facility.

If the inside of the frames are well smoothed, and they are continually kept in gauge, the Pisé walling will present a very substantial and uniform appearance when completed.

The cost of 100 cubic feet of Pisé work on a wall 14′ high and 2½′ thick would probably be as follows, the average lead being about 800′:—

Digging	1 coolie ...	...	As. 4
Carrying earth	4 women ...	...	8
Ramming, including putting up and taking down boxes ...	6 coolies ...	...	1-8
Screening, breaking up earth. .	1 coolie ...	...	4
Watering	1 woman ...	...	2
Cost of box, 1 box being able to turn out 5,000 cubic feet		...	8
Baskets, ropes, repairs, &c. ...	... ...	...	4
			Rs. 3-6

It requires only one day to fix and fill one Pisé box (with half the labour given above, each case containing 50 cubic feet). The work was generally conducted in the following manner. In the morning the boxes were taken down, and again put up and filled during the day; they were left during the night, so that the earth might detach itself from the sides. It is not advisable to allow a course to dry thoroughly, as the upper one will not bind well into it, but probably show a crack. If the earth is well rammed, and only the proper quantity of moisture admitted, a second course can be commenced at once.

The rate for concrete work would probably be Rs. 2 per 100 cubic feet in addition to the cost of the concrete.

P. C. Concrete Arch.—An experimental arch of 75′ span 7½′ rise made entirely of concrete, has lately been constructed over the Metropolitan Railway, and has proved quite successful. The concrete was 3½′ thick at the crown of the arch increasing towards the haunches, which abut on concrete skew backs. The concrete was composed of 1 part of Portland Cement to 6 parts of gravel carefully laid in mass upon close boarding set upon the centring and enclosed at the sides.

Major James Browne, R. E., recommends that all arches should be elliptical and not segmental; as in a segmental arch the stones work down from the ramming into the corner formed between the arch and the abutting block, and the mortar of the concrete works up.

Concrete Walls.—At Rawul Pindee Jail walls 16′ high 2′ thick have been built entirely of concrete composed of

12	cubic feet	lime,
20	„	soorkee,
100	„	gravel,

carried up in 6″ layers and rammed. The flat arches over doors and verandah pillars were made of the same material.

Beton Pise′.—Mr. Coiguet has, as the result of a series of experiments, given récipes for making 2 kinds of concrete suitable for house building, which he distinguishes by the epithets of Economic Concrete and Hard and Solid Concrete. The first is composed of—

Sand, gravel, and pebbles	7 parts.
Argillaceous earth	3 „
Quick-lime	1 „

This concrete, he says, properly beaten up and mixed, has given walls nearly as hard as the common soft rubble masonry used in Paris. In price it competes with ordinary Pisé, over which, however, it has the advantage of being able to resist moisture. The hard concrete is composed of—

Sand, gravel, and pebbles	8 parts.
Common earth burnt and powdered	1 „
Cinders powdered	1 „
Unslaked hydraulic lime	1½ „

The materials to be perfectly beaten up together. Their mixture gives a concrete which sets almost immediately, and becomes in a few days extremely hard and solid, which property may be still further increased by the addition of a small quantity, say, one part of cement.

Extract from the Report on the Paris Exhibition of 1855.

A house three stories in height 65′ × 45′ standing on a terrace having a perpendicular retaining wall has been actually constructed with every part, without exception, of this concrete (béton dur). * * * The use of plaster in the interior is also avoided, as the concrete makes a surface sufficiently fine for papering.

Aqueduct of La Vanne, 135 *miles long, constructed towards the close of the late French Empire to bring into Paris the water of La Vanne River.*—The greatest difficulties met with were in the forest of Fontainebleau, a distance of 37 miles entirely destitute of good building material, and cut up by immense hills of almost impassable quicksand.

To this section the Beton Coiguet construction (afterwards continued through nearly the whole work) was begun.

The Fontainebleau section is composed of a series of arches, some of them as much as 50′ high, 8 or 10 bridges of large span (75′ to 90′) are also included, all made of solid masses of (Beton Coiguet).

The composition of this concrete was—

For foundation and gravel walls, sand and gravel in equal parts 5; hydraulic lime 1, Portland Cement ¼ parts. For pillars, abutments, &c., sand, and in some cases gravel, 4, hydraulic lime 1. The other portions were made from sand 4, hydraulic lime 1, Portland Cement ¼ to ½.—*Scientific American*, 25th March 1876.

New pavement in Newgate Street.—85 per cent. ground granite, 15 per cent. bitumen, laid in a heated semifluid condition two inches thick upon 9′ foundation of Portland Cement Concrete.—*Scientific American*, October 7th, 1876.

Hydraulic Cement.—The following is stated to be an excellent one:—

Eight parts by measure of slaked (Kunkur) lime, 1 part black soil, intimately mixed, made into balls 3″ or 4″ in diameter, burnt and powdered. This mixture will take 6 or 7 of sand to 1 of cement. Tensile strength of some roughly made cement pure of this sort 80 lbs. to the square inch.

Asphalt.—How to fuse and prepare.

A large cauldron or iron pot having been provided and a fire lighted under it, put into it from 100 to 250 lbs. (according to size of pot) of asphalt broken into pieces of not more than ½ lb. each; mix the asphalt with a stirrer in such a way that the pieces at the bottom are constantly brought from the bottom to the surface.

When the whole quantity is thoroughly fused, sand or grit is to be added in the proportion of 2 parts sand to 1 of asphalt; the sand should be added gently and constantly stirred for the purpose of keeping the contents of the boiler properly mixed, and to prevent their becoming burnt and clinkered to the sides and bottom of the boiler. When fit for use the compost will emit jets of light smoke and freely drop from the stirrer; it should then be raised as rapidly as possible to prevent its becoming overburnt.

Directions for applying the compost.—Having provided gauges of the required thickness, place one with weights bearing on its outer edge, parallel to one of the sides of the floor to be covered, and at a distance of about 3 feet; this will form the width of the several layers of pavement or flooring to be covered. In this space the spreader kneels, and as soon as the compost is poured down, it is to be spread with a trowel. To facilitate this work, an ordinary floating rule or piece of hard, straight wood, about 3½″ in length, may be used to level the compost to the thickness of the gauge; and any unevenness in the surface may be easily corrected by the trowel or hand-float.

Before the compost becomes hard a small quantity of very fine sand should be shifted over it, and well rubbed into it with the hand-float.

The contents of each cauldron should be sufficient to cover one layer, and it should be poured all along the space to be covered. If a considerable quantity remain, the gauge may be widened; but if only a small quantity, it should be put back into the cauldron and boiled over again with the next supply.

When the first layer is finished the adjoining space should be covered at a later period. (The object of leaving alternate vacant spaces is that the workmen employed in rubbing may not have occasion to kneel on any part of the asphalt until cool, nor should the gauge be removed till the asphalt has become set).

Adjoining this vacant space, two gauges are then to be laid down at the same distance apart and weighted as before mentioned. The space between the gauges must then be covered with the compost and rubbed in the manner before described. In about ½ an hour the compost will have become quite firm, when the gauges should be carefully removed. The sides of gauges should be oiled to prevent their sticking.

For the flooring of rooms or tops of arches, a layer ¾ths of an inch thick will be sufficient; but for pavements, where there is much foot traffic, the thickness should be increased from an inch to an inch and a half.

Laying Mosaic Floors.—Mix 1 part powdered brick with slaked lime and spread it to a depth of 2 to 2½ inches over the masonry bedding; bring the surface to a fine level. This should be done in small pieces at a time, to prevent their drying instantaneously. On this lay a thin layer of cement prepared with two parts of sifted slaked lime, one of powdered marble, and one of Puzzolana, mixed to a consistency of paste; it should not be thicker than ⅛th of an inch spread over the surface; this after a lapse of 4 hours may be considered ready to receive marble pieces. If it is to form a pattern with designs, define the outlines into their respective colours by hammering in the marble pieces, taking their best sides to form the outlines, the size of pieces to be 1½ inches cube, or less, according to the size of the diagram; after which fill in the spaces with pieces of their respective colours according to the design. When this is done, a stone roller about 12 inches diameter, and 1′ 6″ to 1′ 9″ long, is passed over the surface gently, water being sprinkled every now and then; this carefully done for about 4 hours will bring all the pieces of marble to an even surface, and will work up the cement below between the interstices. The next process its to allow the surface so prepared to dry for 24 hours, after which rub the same with a piece of pumice stone 9″ × 10″ × 3″ fixed to a wooden handle 6 feet long; this polishes the surface, as well as works up the conical pieces of marble to an even and smooth plane. This will have to be done for at least two weeks. The last process is to allow the floor to dry for some weeks before its use. If extra polish is required, rub the surface with tripoli powder and powdered blue vitriol or sulphate of copper with a few drops of vinegar or dilute acetic acid; this will produce a fine polish.

To utilise broken Tiles in Pattern Floors.—Bring the concrete floor to a level ¾ inch lower than the true level of the floor when complete; on this when dry lay a thin layer of Portland Cement or neroo chunam, say $\frac{1}{10}$ inch deep, and arrange the pieces of tiles, taking a small portion at a time, in order to prevent too rapid drying,

of such design as the different colours may suit to form a pattern either mixed or of different coloured strips. When laid, sprinkle dry cement or neroo over the surface, passing the roller as described in the Italian floors. An hour or two manipulation will set closely all the pieces compactly and form a nice surface. Greater care will have to be bestowed in arranging or laying the pieces of tiles than in laying the pieces of marble. When the floor is quite dry, which will take about three weeks, wash it with water, rubbing the surface with pumice stone; a slight rubbing with oil will bring out all the rich colour of tiling.

Trellis Work in Chunam.—The place where the trellis work is to be made is first built up with a thin wall to serve as a temporary backing. The lime (from blue limestone) is then slaked and allowed to remain so for half an hour. When it is sieved, ⅛ of fine soorkee is added and whole well mixed, care being taken not to add too much water. A clean even space is then prepared on the ground, and the mortar spread over it in the layers 2″ or 3″ thick, and as soon as it is sufficiently hard it is divided by the trowel into bricks about 6″ × 4″.

A wall of these bricks is then built up in front of the backing above mentioned, and a small quantity of the finest mortar used to cement them together and the wall surface is carefully levelled by floats and straight edges. It is allowed about a day to dry.

The next day the pattern is drawn on it and the hollow spaces cut out with fine pointed trowels or chisels, water being sprinkled on the work as it proceeds to keep the place moist. The pattern is cut right through to the backing, which is removed as soon as the trellis is dry enough to stand by itself. It can be polished to present the appearance of marble if required.

Wood Work.

The principal woods in use in this Presidency are as follows :—

Unjun.—Hardwickia Binata.—A large tree growing in the Godávari forests and elsewhere, very tall and straight. The wood is dark coloured, and heavy, and of an excellent quality for posts.

Babul.—Acacia Arabica.—The tree seldom attains a greater height than 30 to 35 feet, or a greater thickness than 2 feet. The wood is of a light red colour, close grained, hard and tough, and, though rather heavy, is preferred for many purposes on account of its durability.

Blackwood.—Dalbergia Latifolia.—This timber has white wood surrounding the body and heart, which last is of a blackish brown colour; the ring in this case does not exceed 1½″ in breadth. The dark wood is exceedingly heavy, being exactly the same weight as water. It is stated to be as strong as teak, and if all sap wood is cleared off as good as teak for work not exposed to weather. Stands exposure

well, is sound under water; but when alternately wet or dry decays rapidly; splits considerably when exposed to the sun and blows of pile driver.

Mutti.—Terminalia Tormentosa.—Wood of a reddish brown colour, hard, heavy, durable under water, rather coarse in fibre, and difficult to work. In seasoning the grain is apt to open. Requires 12 to 15 months to season; is not readily touched by white ants.

Teak.—Tectona Grandis.—Too well known to need description. The best teak in the Bombay market comes from Moulmein. Calicut teak is now scarcely obtainable.

Pine.—American, obtainable in the Bombay market.

Cedar.—Singapore, a reddish wood, not unlike benteak in appearance; very light; obtainable in Bombay market about the same price as American pine.

Australian Gum.—It is a pity that more of this class of wood is not imported, as its properties of lasting under water are stated to be far superior to those of any Indian woods, teak not excepted.

Jarrak, or *Australian Mahogany,* is also said to be an excellent wood.

Honay.—Pterocarpus Marsupium.—A pretty wood and easily worked; used in the interior of houses; not durable when exposed.

Jamba.—Inga Xylocarpa.—This valuable timber tree known as the *Iron wood* of Arracan is found throughout Southern India and Burmah, furnishing a wood of very superior quality, heavy, hard, close-grained, and durable, and of a very dark red colour: it is, however, not easily worked and resists nails. It is extensively used for bridge building, posts, piles, &c., and is a good wood for sleepers, lasting (when judiciously selected, and thoroughly seasoned) for six years.

Arjun—Terminalia Arjuna.—A tree widely diffused, often found in company with teak, and growing to a very large size. It furnishes a dark brown, heavy, very strong wood, suitable for masts and spars, beams and rafters.

Bakool.—Mimusops Hexandra.—This tree grows in South India and Gujarát, and furnishes wood, heavy, close and even-grained, of a pink colour, standing a good polish: used for cabinet making purposes and ordinary house building.

Honagi.—Nauclea Cordifolia.—This is a very large tree, with a soft, close, even-grained wood, but light and more easily worked, and very susceptible to alternations of temperature. It is esteemed as an ornamental wood for cabinet purposes.

Hurda.—Terminalia Chebula.—A beautiful and lofty tree with horizontal branches, growing in tiers; planted in gardens and avenues. The wood is used in Southern India for common house building, but it is light and coarse-grained, possessing little strength, and liable to warp. In Burmah it is used for yokes and canoes. The fruit and galls are used by dyers.

Jack.—Artocarpus Integrifolia.—The common 'jack fruit' tree is of rapid growth, and reaches a very large size. It is found all over India and is esteemed both for its fruit and timber, and with its abundant dark foliage and numerous pendent fruit is a handsome object. The wood when dry is brittle, and has a coarse and crooked grain. It is, however, suitable for some kinds of house carpentry and joinery; tables, musical instruments, cabinate and marquetry work, &c. The wood when first cut is yellow, afterwards changing to various shades of brown.

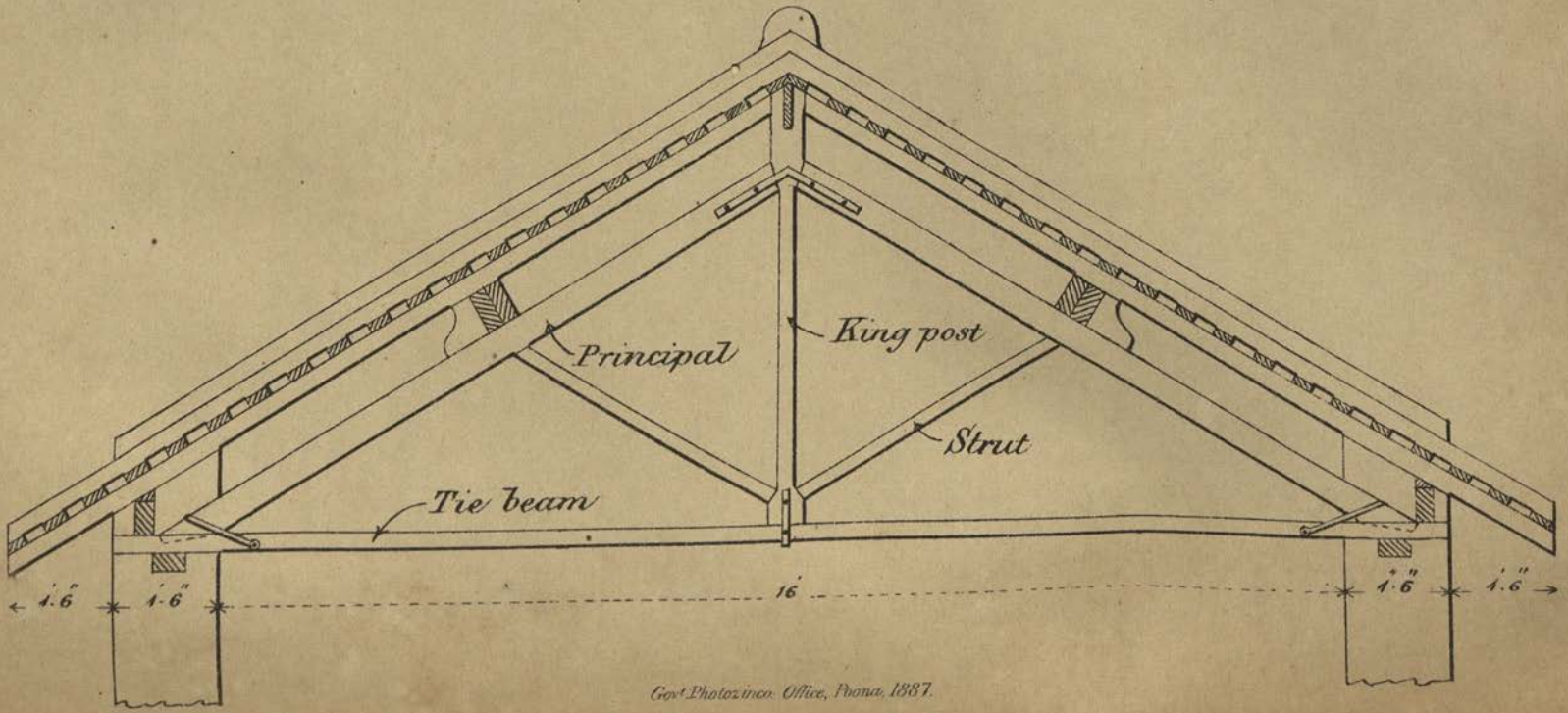
Kalamb.—Nauclea Parviflora.—A large fine timber tree; with a wood of fine grain, easily worked, used for flooring planks, packing boxes and cabinet purposes; it is much used by the wood carvers of Saharunpore.

Mango.—Mangifera Indica.—The *Mango* is generally diffused over all the warmer parts of Asia, and is much esteemed for its fruit. Its wood, however, is of inferior quality, coarse and open grained, of a deep gray colour, decaying if exposed to wet, and greedily eaten by white ants. It is, however, largely used, being plentiful and cheap, for common doors and door-posts, boards and furniture, and also for firewood. It should never be used for *beams*, as it is liable to snap off short.

Sirris.—Acacia Speciosa.—The '*Sirris*' is a common tree throughout India, and with its rapid growth, its large head of handsome foliage and sweet scented flowers, is a good avenue tree. It grows to 40 or 50 feet in height and 5 to 6 feet in girth; the wood is said by some writers to be hard, strong, and durable, never warping or cracking, and to be used by the natives of South India for naves of wheels, pestles and mortars, and for many other purposes: but in Northern India it is held to be brittle, and fit only for such purposes as box planks and for firewood.

Tamarind.—Tamarindus Indica.—The *Tamarind* is a very handsome tree for avenues, gardens, &c., of very slow growth, but attaining a great size, and much valued for its fruit. The heart wood is very hard, close grained, dark red, very hard to be worked; used for turnery, also for oil presses and sugar crushers, mallets, and plane handles; it is a very good brick burning fuel.

King Post Truss.



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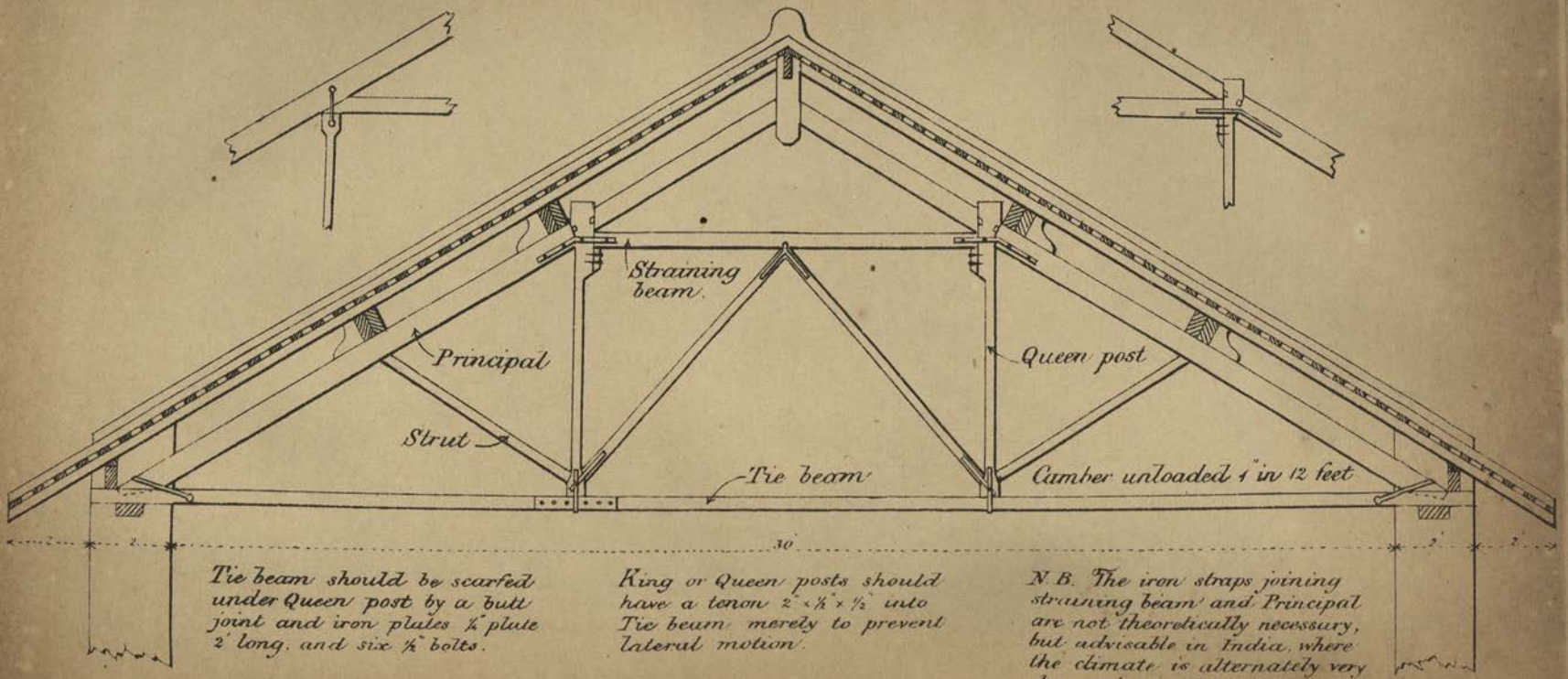
Queen Post Truss.



Tie beam should be scarfed under Queen post by a butt joint and iron plates ¼" plate 2' long, and six ½" bolts.

King or Queen posts should have a tenon 2" × ½" × ½" into Tie beam merely to prevent lateral motion.

N.B. The iron straps joining straining beam and Principal are not theoretically necessary, but advisable in India, where the climate is alternately very dry and very damp

Govt. Photozinco. Office, Poona. 1887

Scarfing & Joints of Principals with Tiebeam

Plate XXII.

Fig. I.

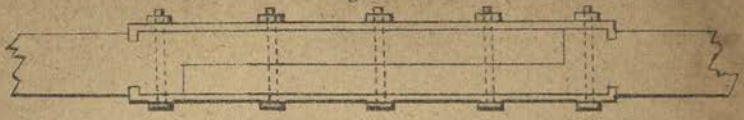


Fig. II.

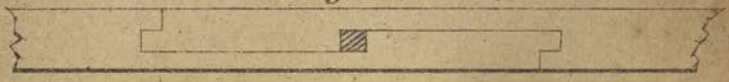


Fig. III.

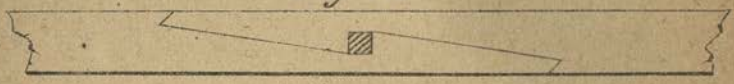


Fig. IV.

Fig. V.

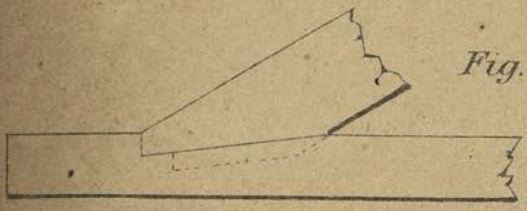


Fig. VI.

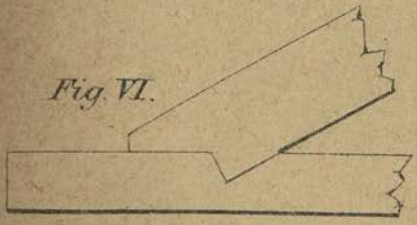


Fig. VIII.

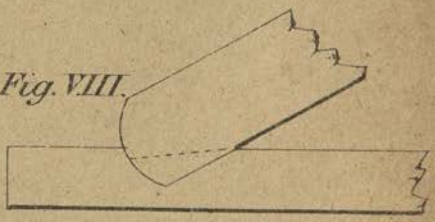


Fig. VII.

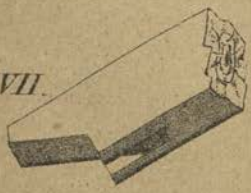
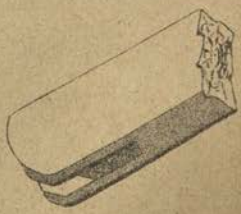


Fig. IX.



Govt Photozinco Office Poona 1887

Joints of Principals, Struts &c. with King & Queen posts.

Fig I.

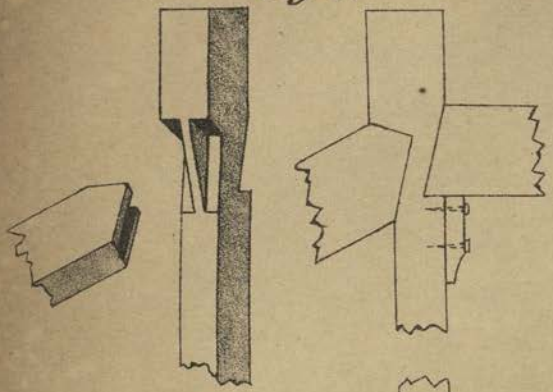


Fig. III.

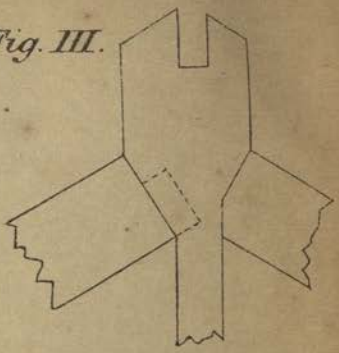


Fig. II.

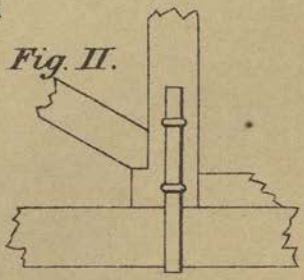


Fig. IV.

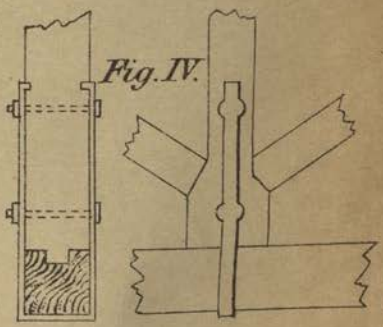


Fig. V.

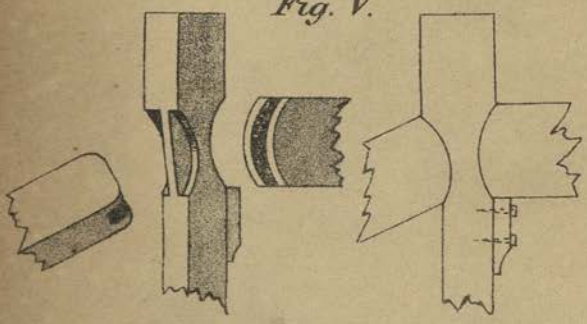


Fig. VII.

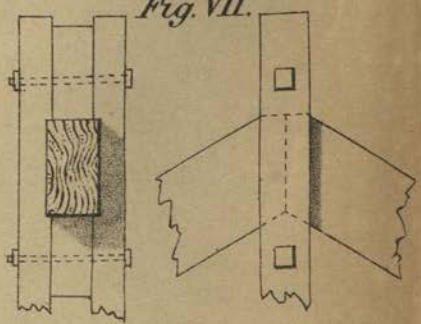


Fig. VI.

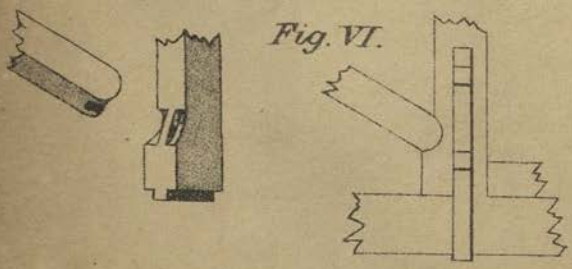
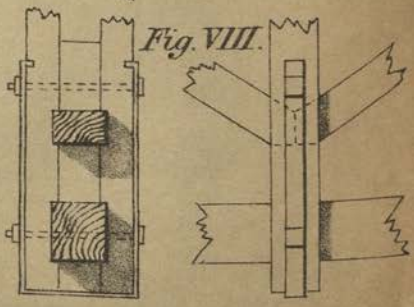


Fig. VIII.



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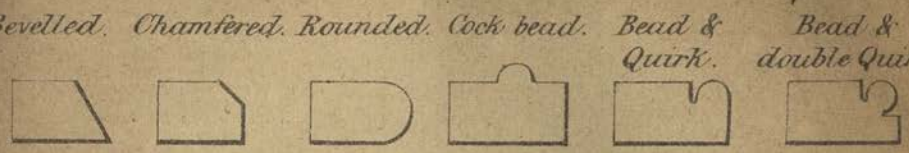
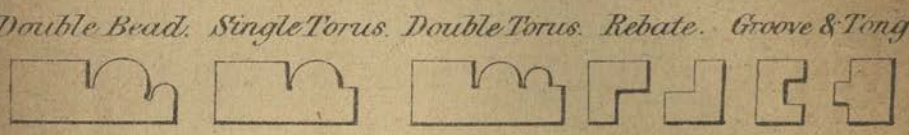
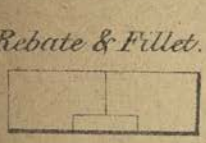
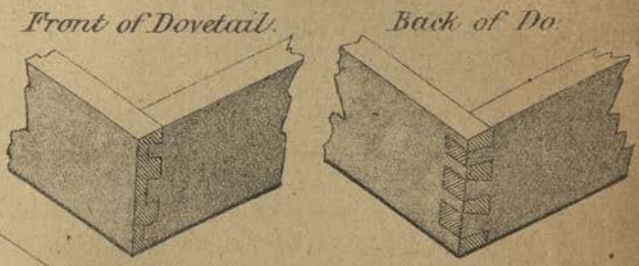
Joinery.

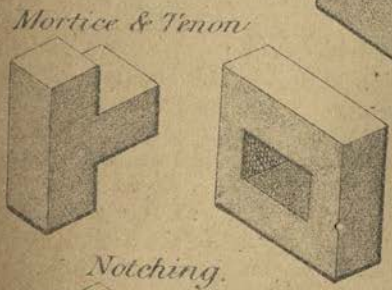
Plate XXIV.

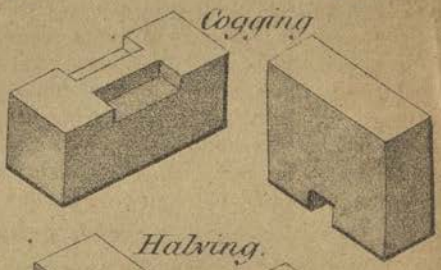


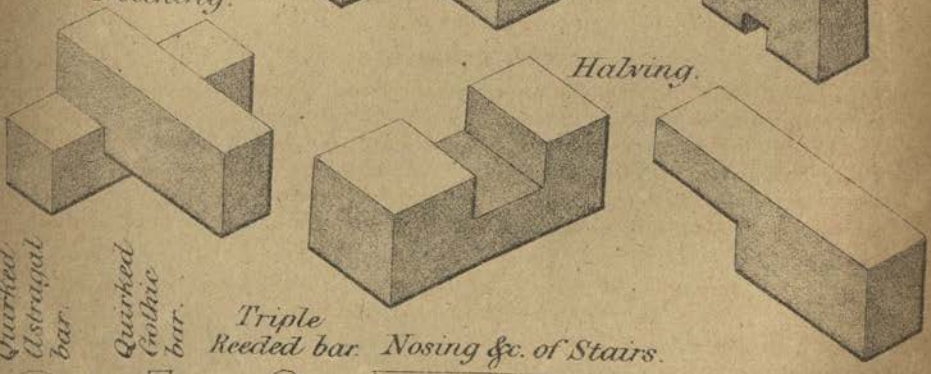


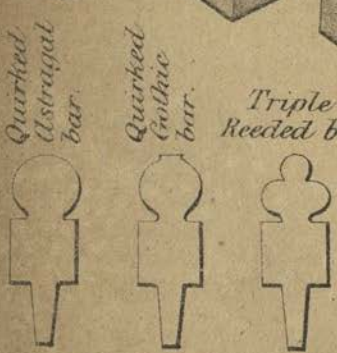


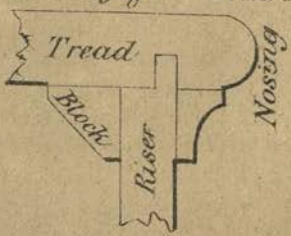












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LIST OF THE PRINCIPAL TREES IN THE BOMBAY PRESIDENCY.

Local Names.	Botanical Names.	Weight in lbs. of a C.F. of seasoned wood "W."	Co-efficient of Deflection elasticity in lbs. per Square Inch "Ed." I.	Intensity of direct Ultimate stress or Tenacity in lbs. per Square Inch "ft." (Tensile).	Intensity of Dead Breaking weight in lbs. per Square Inch "p." (Cross strain.)
Unjun	Hardwickia Binata	85	4579	12016	942
Babul	Acacia Arabica	54	4111	16815	876
Blackwood ..	Dalbergia Latifolia	50	4053	20288	912
Mutti	Terminalia Tormentosa	60	4043	22351	860
Teak	Tectona Grandis	42	3978	14498	683
Honay	Pterocarpus Marsupium	56	4132	19943	868
Jamba	Inga Xylocarpa	58	4283	16657	836
Arjun	Terminalia Arjuna	54	4094	16288	820
Bakool	Mimusops Hexandra	70	3948	19036	944
Honagi	Nauclea Cordifolia	42	3052	10431	506
Hurda	Terminalia Chebula	32	3108	7563	470
Jack	Artocarpus Integrifolia ..	44	4030	16420	788
Kalamb .. .	Nauclea Parviflora	42	..	....	400
Mango	Mangifera Indica	42	3120	7702	560
Sirris	Acacia Speciosa	55	3502	....	532
Tamarind ..	Tamarindus Indica	79	2803	20623	816

Teak Trusses.

For dimensions of trusses see Tables XVII to XXII.

Verandah Posts.—It is not an uncommon thing in this country to see verandah posts forced outwards by the thrust of the roof, owing to the tops of the rafters not being securely fastened to wall plates, but simply laid in the wall. A very good illustration of this can be given by laying a stick hooked at one end on the back bar of a chair, and letting the lower end rest on brick standing on its end. If the stick is hooked to the back of a chair and a pressure applied in the centre, the brick will fall inwards; but if the stick is not hooked, when pressure is applied the brick falls outwards.

Iron Trusses.

1. The table on the following page gives the dimensions of the different parts of some iron roofs of the simplest form for spans of 20, 30, 40, and 50 feet as shown in outline on Plate No. XXV and details on Plate No. XXVI. The principal rafters and struts which are of T iron are of sections which can always be procured without difficulty. The tie rods, and king and queen bolts are of round and rod iron of ordinary section.

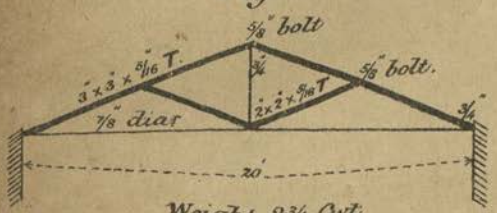
2. The strength of the different parts is calculated for a wind pressure of 40 lbs. per square foot covered, and for principals placed at either 8 or 12 feet apart, (see Table) covered with any ordinary materials, not exceeding 15 cwt. in weight per square. The outlines of the roofs are shown in figures 1 to 4 of Plate XXV: in this case the trusses are supposed to be 8 feet apart. The roofs are designed to have a pitch of 1 in 2, that is an angle of 26°35′ with the horizon, and the main tie rods have a pitch 1 in 12½. The principal rafters of roofs of 50 feet span consist of 2 angle irons, as shown in sketch, instead of ordinary tee iron.

Scantling of Iron Trusses.

Span in feet.	Rise in centre.	Rise of tie rod.	Distance apart of King and Queen bolts.	No. of pairs of Queen bolts.	No. of pairs of struts.	Principals. Top table.	Principals. Depth.	Principals. Thickness.	Struts. Top table.	Struts. Depth.	Struts. Thickness.	Diameter of Tie rod.	Diameter of King bolt.	Diameter of Queen bolt.	Diameter of Queen bolt 2nd pair.	Weight of Truss in Cwt.
			Principals 8 feet apart.													
20	5	1 in 12½.	...	...	1	3	3	5/16	2	2	5/16	7/8	3/4	...	...	2¾
30	7½		5	1	2	3	3½	5/8	2	2½	1/4	1⅛	3/4	1/2	...	5½
40	10		6⅔	1	2	3	4	1/2	2½	2½	5/16	1⅜	7/8	1/2	...	9½
50	12½		8⅓	2	2	Angles. 3	4	3/8	3½	3½	3/8	1½	1	5/8	1/2	16
			Principals 12 feet apart.													
20	5	1 in 12½.	...	...	1	2½	3½	3/8	2½	2½	5/16	1⅛	3/4	...	...	3¼
30	7½		5	1	2	3	4	7/16	2	2½	3/8	1½	1	1/2	...	7
40	10		6⅔	1	2	4	4½	5/8	3	3	3/8	1⅝	1⅛	1/2	...	13¼
50	12½		8⅓	2	2	Angles. 3	4	1/2	3½	3½	3/8	1⅞	1¼	5/8	1/2	21¾

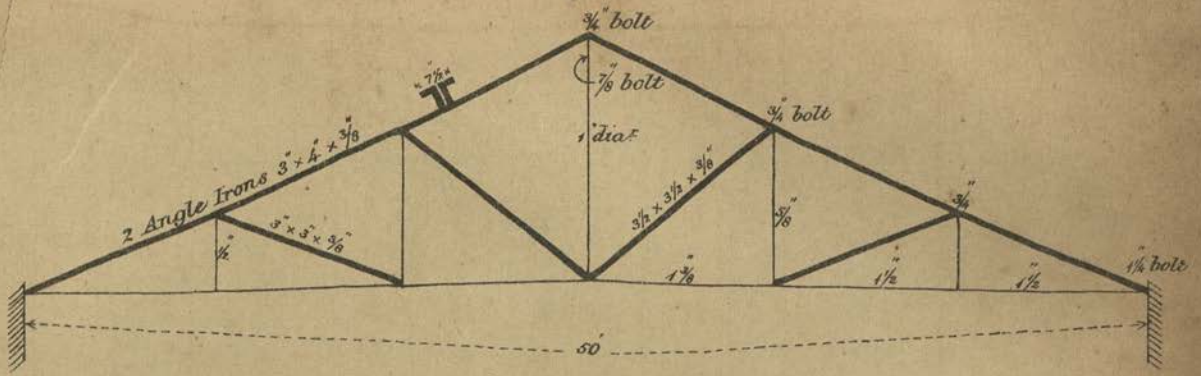
Iron Roofs and Details.

Fig. 1.



Weight 2¾ Cwt.

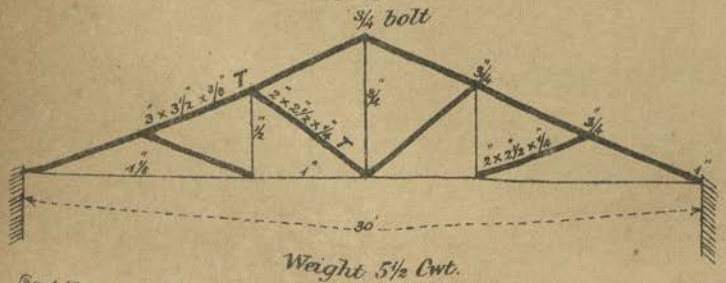
Fig. 4.



Weight 16 Cwt.

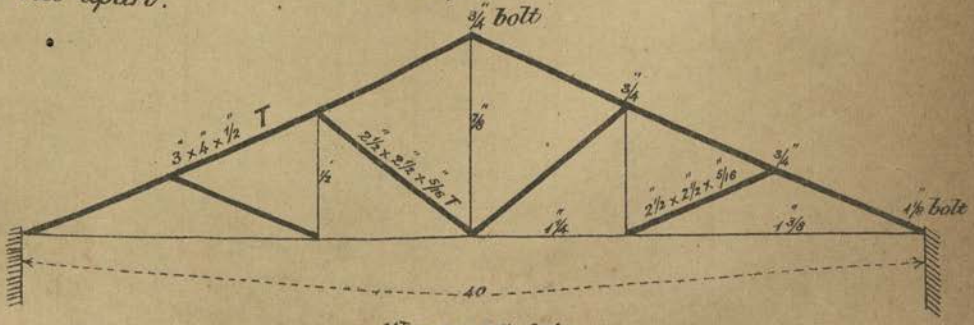
N.B. Trusses 8 feet apart.

Fig. 2.



Weight 5½ Cwt.

Fig. 3.



Weight 9½ Cwt.

Scale, 1/8" = 1 foot.

Govt Photozinco Office, Poona, 1887

Fig. 1.

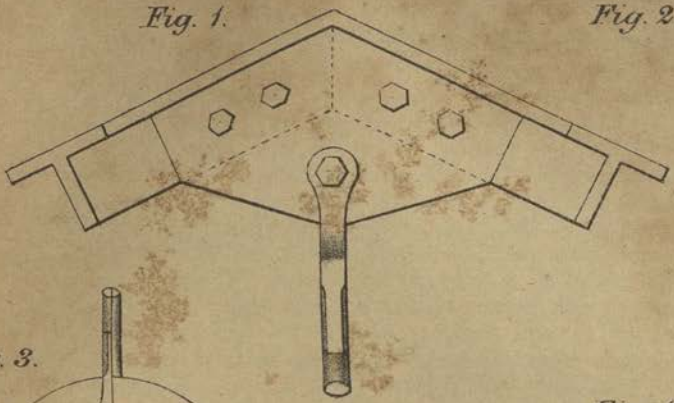


Fig. 2.

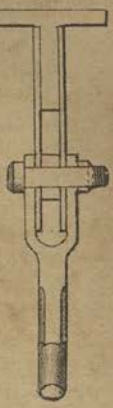


Fig. 3.

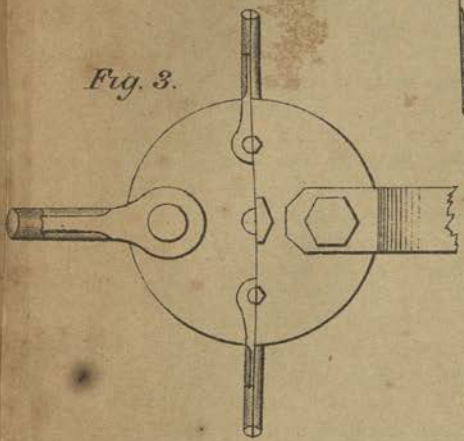


Fig. 6.

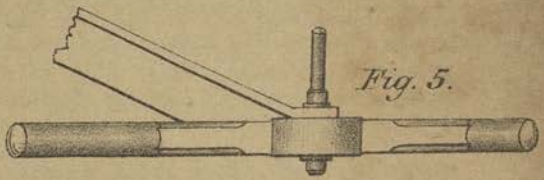


Fig. 5.

Fig. 4.

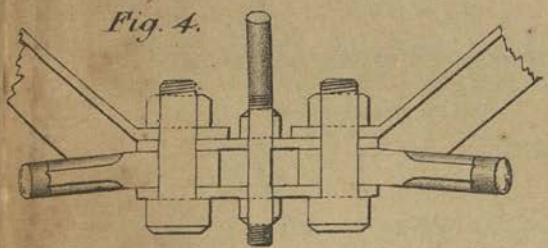


Fig. 7.

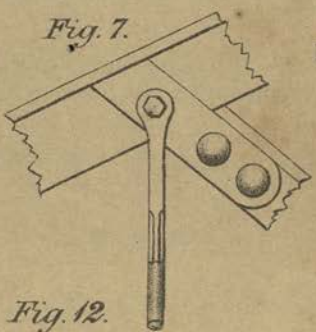


Fig. 8.

Fig. 12.

Fig. 11.

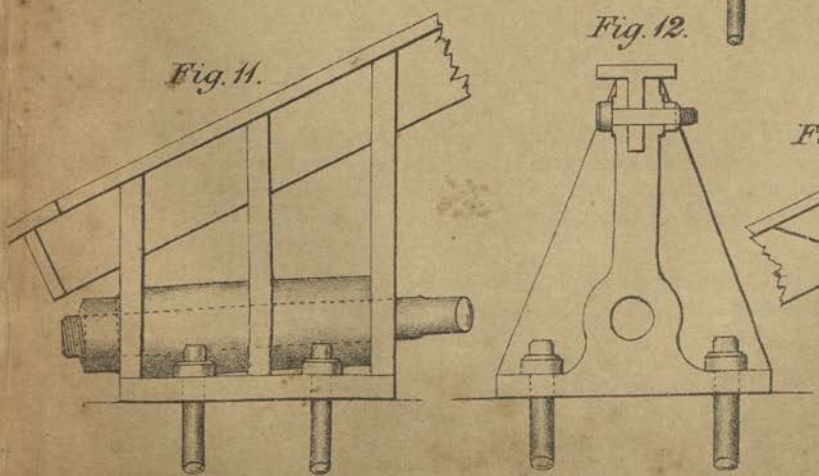


Fig. 9.

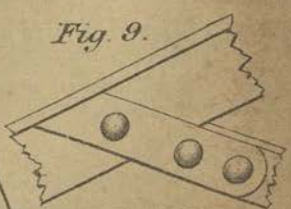


Fig. 10.

Govt Photozinco Office, Poona, 1887

3.—Figs. 11 and 12 represent the method of securing the tie rod and rafter in a cast iron shoe: the shoe is secured to the masonry by means of holding-down bolts, secured to a plate of iron built into the wall. The tie rod is capable of being lightened up by means of the screwed bolt and nut at back. The other ends of the tie rods are formed with eyes; and connected to two wrought iron plates as shown at Figs. 3 and 4 by bolts and nuts: the same bolts also connect the struts of which the ribs are cut off and the ends of the top flange bent and punched for the purpose. The king bolt passes through a hole in the middle of each of these wrought iron plates, and is screwed at the end and has a nut above and below. The plan of these wrought iron plates also shows two holes at right angles with those for securing the tie rods. These are for the purpose of securing in a similar manner longitudinal tie rods where they are deemed necessary. At the points where the struts meet the tie rods the latter are forged with eyes as shown in Figs. 5 and 6, and the queen bolts, struts and tie rods secured together as these shown. Figs. 9 and 10 represent the method of connecting the upper end of the struts with the queen bolts and rafters. The end of the struts is bevelled off to range with the under side of the rafter, and reveted to two strips of plate iron, one on each side of it. The end of the queen bolt is forged with a jaw, Figs. 7 and 8, and holes formed in it through which, and also a corresponding hole in the rafter, a bolt passes and is secured by a nut. The heads of the rafters and the king bolt are secured together by means of two wrought iron plates as shown in Figs. 1 and 2; the king bolt being secured to the latter by means of a screwed bolt and nut passing through holes bored in them. The two plates must be stiffened and kept apart by means of a packing piece through which the same bolt and nut pass.

Galvanized Iron Roof Covering.—For buildings no corrugated iron of less than 20 gauge should be used, 22 and 24 gauge being only suited for temporary sheds.

The following are the approximate weights per square for the different gauges:—

No.	14	gauge	weight	300	lbs.	per square.
„	16	„	„	260	„	„
„	18	„	„	236	„	„
„	20	„	„	190	„	„
„	22	„	„	150	„	„
„	24	„	„	130	„	„

Venetian Blinds.—In a plank about $4\frac{1}{2}''$ wide and $1''$ thick, screwed securely to the top of the opening, are cut slots to receive pulleys about $1''$ diameter, either of brass or box-wood. Care must be taken not to make these slots wider than to permit of the pulley working freely.

Slots $1\frac{3}{4}''$ long $\frac{1}{2}$ diameter are also cut in this to receive rollers, round which tapes of cotton webbing fastened by brass-headed studs to the bottom of the top blade $3''$ wide work freely.

Ordinary blades are about $\frac{3}{8}$" thick ; the top blade should be somewhat thicker. The blades when blind is closed, overlap about $\frac{3}{4}$".

The two cords by which the blinds are raised or lowered are fixed to the bottom blades ; each pass through all the blades of the venetians and over two pulleys in top plank, and then are taken down and fastened or regulated at a hook in the jambs, or by patent clips which keep the blind up to any required height.

The ends of tapes about $1\frac{1}{2}$" wide of cotton webbing, are fastened to the top blade on either side of the holes through which the cords pass, and the blades are supported on narrow tapes the same length as the width of the blades sewn across from alternate sides of the broad tape ; the bottom of the latter is fastened by brass-headed studs to the bottom of the lowest blade. Two tapes are generally sufficient, but if opening is broad, three are sometimes used.

PAINTS, WASHES, VARNISHES, &c.

Painting is to protect materials from the action of heat, gases, moisture, &c., by covering them with an almost impervious and durable coating. One of the most effective compositions used for this purpose is a mixture of white lead and linseed-oil.

The latter forms the durable coating ; it possesses the property of drying after it has entered the surface of the materials into a resinous compound, thus filling up the pores and preventing decaying action. The "dryer", which is some oxidising substance such as litharge, is added to expedite the process, and a solvent such as spirits of turpentine is added to dilute the mixture ; this soon evaporates again. The white lead gives body and opacity to the mixture ; it combines readily and to a certain extent chemically with the oil into a saponaceous substance. White lead is the carbonate of lead. It is a fine white powder weighing about 400 lbs. to the cubic foot. It is often adulterated by whiting, sulphate of baryta, etc. Tests.—Specific gravity, or by resolving the powder back into metallic lead, which should weigh less than the powder ; or, in the case of the sulphate of baryta to which is the most usual adulteration, by nitric acid which will dissolve the lead, but not the baryta. Linseed-oil in its natural condition dries slowly to the resinous varnish, and rather injures the brilliancy of delicate colours. Boiled linseed-oil also causes it to oxidise quicker, but, as it makes the oil thicker, is not so well suited for delicate work Linseed-oil can be clarified by mixing it with an acid such as oil of vitriol ; it must be well washed with water to get rid of the acid. In instances where the least yellowness in the oil would be injurious, nut or poppy-oil may be used with advantage.

Dryers.—Drying is an oxidising process. The ordinary dryer is "litharge" or oxide of lead. Oxide of manganese is also used, and is a quicker dryer than litharge. The proportion of litharge is about $\frac{1}{4}$ lb. to a gallon of oil. The oil is then called a drying oil, and can be made clear and colourless by leaving it exposed to the air in shallow vessels for two or three days. It should be observed that in the finishing

coats of delicate colours, dryers are generally avoided, as they have a slight tendency to injure the colour.

Solvents are required to dilute the mixture of white lead and oil, which would not otherwise penetrate into the pores of the material. Spirits of turpentine is generally used for this purpose ; it is a solution of resin in spirit, and evaporates perfectly. The best test for its purity is evaporation. It deteriorates by keeping.

Pigments.—The object of adding pigments to the drying oil is to give it opacity, body, and colour.

Zinc White is the oxide of zinc ; it is cheaper than, but not so durable as, white lead. It is light and not opaque, and is readily attacked by salts and therefore is not durable, and is easily acted on by wet and acids in wood. It does not dissolve so readily as white lead, and as long as it lasts it keeps its colour better than white lead and is not so easily adulterated, it takes longer in drying, and when adulterated is liable to change colour. Lead dryers should not be used with zinc, as they become black. when exposed to sulphuretted hydrogen ; white sulphate of manganese is the best dryer.

Red Lead is the oxide. of lead ; on account of its durability it is frequently used as a priming or first coat on iron work ; care should be taken that no salts are present.

In laying on the paint the white lead, oil and dryer are mixed to the consistency of thick cream on a flat stone, and the coating matter is then added. The brush should be held at right angles to the face of the work, so that only the ends of the hairs touch it.

The first or priming coat need have very little, if any, of the final colouring matter in it ; after priming all nail holes, &c., are stopped. For fine work each coat should be carefully rubbed down with pumice stone or glass paper, and dusted before the next coat is added.

Painting old work.—If work is much soiled, it should be washed with soap and water and scoured ; if foul with smoke and grease, it should be washed with lime and water and rubbed with pumice stone before the first new coat is laid on.

The following is a table of materials required to cover superficial space as under :—

1st Coat ...	10 lbs. white lead. 4 pints linseed-oil. 2 ozs. of litharge. 1 oz. of red lead.	25 superficial yards, or say 2 squares.
2nd Coat ...	10 lbs. white lead. 2½ pints linseed-oil 1½ „ spirits of turpentine. 2 ozs. of litharge.	40 superficial yards, or say 3½ squares.
3rd and subsequent Coat.	10 lbs. white lead. 2 pints linseed-oil. 2 „ spirits of turpentine. 2 ozs. of litharge.	50 superficial yards, or say 4½ squares.

For coloured paints add colour in proportion of 1 lb. to 2 lbs. for every 10 yards of surface, reducing white lead in proportion.

1 oz. of Olphert's oxide with ½ oz. of raw linseed-oil (patent dryers or not as required) will cover a square yard.

$\frac{1}{16}$ resin to 1 of Olphert's paint is a capital dryer.

Glazier's putty is made of whiting and oil. Whiting in form of a very dry fine powder mixed with as much raw linseed-oil as will form it into a stiff paste; this, after being well pounded, should be left for 12 hours and worked up in small pieces till quite smooth. It should be kept in a glazed pan and covered with a wet cloth. If putty becomes hard and dry, it can be restored by heating it and working up again while hot. For special purposes white lead is sometimes mixed with the whiting, or putty is made of lead and litharge entirely.

Distemper is the name given to paint composed of white lead or other colouring matter ground in water instead of oil and mixed with size to make it set; it is, in fact, a water colour. The colouring materials chiefly employed are *red* and *yellow ochre*, the flowers of the *dhak* tree, the red earth called *hirmzee*, *orpiment*, *indigo*, and *blue vitriol*.

Whiting is pure chalk reduced by levigation to fine powder.

Size is the glue extracted from animal tissue; it is often used by itself as a priming coat.

Colour Washing.—The following description of colour washing refers to this kind of work as executed in Calcutta, and a few récipes are given of some of the most favourite colours. When the walls are rough and not lime-plastered, they are to be enamelled with lime-plaster, so as to make the surface smooth. The thick curd or Châná mixed with lime water, or simply milk and water of equal proportions is to be washed over the surface to form a body for the water colouring.

The water colour to be mixed with ½ milk and ½ water with white of egg and pure China glue, the latter previously boiled in water and made into liquid. The colour so prepared to be laid carefully on the walls in one coat with an English brush, so that no cut shades be visible on the walls.

By using stencil plates of zinc or stiff cardboard, flower or other patterns can be used for borders round doors, &c., with great effect, at a very moderate cost.

Statement showing ingredients for different descriptions of water colouring, borders, &c.

Stone colour ...	Whiting	1 seer.
	Umber burnt	½ chittack.*
	Chrome yellow	2 „
	Glue	2 „
	Vermilion China	¼ tolah.
Canary ...	Whiting	1 seer.
	Glue	2 chittacks.
	Chrome yellow	2 „

*Chittack is the $\frac{1}{16}$ of a seer.

Buff ...	Whiting powder	1 seer.
	Glue	2 chittacks.
	Chrome yellow	2 „
	Yellow ochre	1 „
Green ...	Whiting	1 seer.
	French green	4 chittacks.
	Glue	2 „
Brown ...	Whiting	1 seer.
	Glue	2 chittacks.
	Burnt umber	2 „
	Meena	2 „
Blue ...	Whiting	1 seer.
	Glue	2 chittacks.
	Prussian blue	2 „
Purple ...	Whiting	1 seer.
	Glue	2 chittacks.
	Meena	2 „
	Vermilion China	2 „
Fine white-washing 2 coats.	Stone lime	¼ chittack.
	Water lime	1 seer.
	Shell lime	¾ „

A récipe for white-wash which does not easily rub off on the clothes:—

1 maund clean white or shell lime, slake it thoroughly with hot water in covered vessel.

Add 5 seers salt dissolved in hot water.

3 seers coarse rice pounded or boiled to a thick paste.

½ seer glue cleaned by dissolving in hot water, the dirty refuse being rejected.

Ingredients to be well mixed and brought to the required consistency by the addition of hot water, then allowed to simmer over a fire for a few hours; then strain and lay on hot.

Varnishes.—See General Specification No. XX.

French Polish.—Take plaster of Paris, red ochre or dragon-blood (sufficient to tint it), linseed-oil; mix with a stiff paste, moisten a piece of rag with linseed-oil, rub on wood and then apply mixture sparingly, rubbing it hard in to fill up pores of the wood. Let stand for a few hours and then rub down with fine glass paper. Then put on the polish. Two coats will be sufficient. To finish off, roll a piece of flannel into the form of a rubber, cover with a piece of rag slightly damp with methylated spirit, and rub lightly and quickly with a circular motion; if the rag sticks, touch the wood with linseed-oil. French polish is made by dissolving ¼ lb. brown shellac in 1 pint of spirits of wine or naptha.

The following is an excellent wood or furniture polish:—

16 qts. Linseed-oil.
2 „ Spirits of wine.
1 „ Vinegar.
1 „ Turpentine.
1 „ Copal varnish.
1⅓ pints Muriatic acid.

The oil to be heated and the whole mixed up.

Brass Lacquer.

Pale shellac	... 1 lb.
Gamboge	... 1 oz.
Cape Aloes	... 3 „
Alcohol	... 2 gals.

Gold Lacquer.

Pale shellac	... ¾ lbs.
Sandarach	... 3½ „
Turmeric	... 1 „
Gamboge	... 2½ ozs.
Alcohol	... 2 gals.

Lacquered Brass, to clean.—Rub with a soft cloth dipped in stale beer when the cloth works dry, dip again : this gives a good polish.

CODE OF RULES FOR THE ERECTION OF LIGHTNING CONDUCTORS.*

The following code of rules should be carefully attended to in drawing out a specification for a lightning conductor :—

Points.—The point of the upper terminal should not be sharp, not sharper than a cone of which the height is equal to the radius of its base. But a foot lower down a copper ring should be screwed and soldered on to the upper terminal, in which ring should be fixed three or four sharp copper points, each about 6 inches long. It is desirable that these points be so platinized, gilded, or neckel plated as to resist oxidation.

Upper Terminals.—The number of conductors or points to be specified will depend upon the size of the building, the material of which it is constructed, and the comparative height of the several parts ; no general rule can be given for this. It must be borne in mind that even ordinary chimney stacks, when exposed, should be protected by short terminals connected to the nearest rod, inasmuch as accidents often occur owing to the good conducting power of the heated air and soot in a chimney.

Note.—The conference remarks as follows in regard to the space protected by each lightning rod :—" At present we have not sufficient data to enable us theoretically to calculate the space protected by lightning rod, and therefore we are compelled to draw up our rules upon the question entirely from experience, and here we find that, with the doubtful exceptions already mentioned, there is no recorded instance of a building being struck by lightning within a conical space the radius of whose base was equal to its height, and we think that the adoption of this rule may reasonably be expected to yield that security in the future which, as far as we know, it has done in the past."

Insulators.—The rod is not to be kept from the building by glass or other insulators, but attached to it by metal fastenings.

Note.—" The essentials are (1) that the rod be attached to the building by fastenings of the same metal as itself ; (2) that the fastenings be of adequate strength ; (3) that they be of such form as not to compress or distort the rod ; (4) that they allow play for its expansion and contraction ; (5) that they hold it firmly enough to prevent all the weight falling on any one bearing. "

* From the " Report of the Lightning Rod Conference " published in London in December 1881.

Fixing.—Rods should preferentially be taken down the side of the building which is most exposed to rain. They should be held firmly, but the hold fasts should not be driven in so tightly as to pinch the rod, or prevent the contraction and expansion caused by changes of temperature.

Factory Chimneys.—These should have a copper band round the top, and stout, sharp copper points, each about one foot long, at intervals of 2 or 3 feet throughout the circumference, and the rod should be connected with all bands and metallic masses in or near the chimney. Oxidation of the points must be carefully guarded against.

Ornamental Iron-work.—All vanes, funnels, ridge iron work, &c., should be connected with the conductor, and it is not absolutely necessary to use any other point than that afforded by such ornamental iron work, provided the connection be perfect and the mass of iron work considerable. As, however, there is risk of derangement through repairs, it is safer to have an independent upper terminal.

Material for Rod.—Copper, weighing not less than 6 ozs. per foot run, and the conductivity of which is not less than 90 per cent. of that of pure copper, either in the form of tape or rope of stout wires—no individual wire being less than No. 12 B. W. G. Iron may be used, but should not weigh less than $2\frac{1}{4}$ lbs. per foot run.

Note.—The conference recommend the following as the *minimum* size of each:—

Material.	Pattern.	Diamr.	Area.	Weight per foot.
Copper	Rope	$\frac{1}{2}''$	·10	6 ozs.
„	Round rod	$\frac{8}{8}''$	·11	7 „
„	Tape	$\frac{3}{4}'' \times \frac{1}{8}''$	·09	6 „
Iron	Round rod	$\frac{9}{16}''$	·64	35 „

Joints.—Although electricity of high tension will jump across bad joints, they diminish the efficacy of the conductor; therefore every joint, besides being well cleaned, screwed, scarfed, or rivetted should be thoroughly soldered.

Note.—"Screwed, scarfed, and rivetted joints, however well they may be made mechanically, are certain to rust and corrode in time, owing to the expansions and contractions due to changes of temperature admitting moisture, and thus causing corrosion and resistance. No joint can possibly be electrically perfect that is not *metallically continuous*, and carefully soldering in addition to screwing, scarfing, and rivetting is the only certain mode of securing this. Soldering is a method that has borne the test of experience, and its success as a means of securing perfect joints leaves no excuse for its omission. The fewer joints the better, but where there are joints they can only be made electrically secure by careful soldering."

Protection.—Copper rods, to the height of 10 feet above the ground, should be protected from injury and theft, by being inclosed in an iron pipe reaching the same distance into the ground.

Painting.—Iron rods, whether galvanized or not, should be painted: copper ones may be painted or not according to architectural requirements.

Curvature.—The rod should not be bent abruptly round sharp corners. In no case should the length of the rod between two points be more than half as long again as the straightline joining them.

Where a string course or other projecting stone work will admit of it, the rod may be carried straight through, instead of round the projection. In such a case the hole should be large enough to allow the conductor to pass freely, and allow for expansion, &c.

Extensive masses of Metal.—As far as practicable it is desirable that the conductor be connected to extensive masses of metal, such as hotwater pipes, &c., both internal and external; but it should be kept away from all soft metal pipes, and from internal gas pipes of every kind. Church bells inside well protected spires need not be connected.

Earth Connection.—It is essential that the lower extremity of the conductor be buried in permanently damp soil; hence proximity to rain water pipes and to drains is desirable. It is a very good plan to make the conductor bifurcate close below the surface of the ground, and adopt any of the following methods for securing the escape of the lightning into the earth :—

A strip of copper may be led from the bottom of the rod to the nearest gas or water main—not merely to a lead pipe—and be soldered to it; or a tape may be soldered to a sheet of copper 3 ft. × 3 ft. and $\frac{1}{16}$ inch thick, buried in permanently wet earth, and surrounded by cinders or coke; or many yards of the tape may be laid in a trench filled with coke, taking care that the surfaces of copper are, as in the previous cases, not less than 18 square feet. Where iron is used for the rod, a galvanized iron plate of similar dimensions should be employed.

Inspection.—Before giving his final certificate the architect should have the conductor satisfactorily examined and tested by a qualified person, as injury to it often occurs up to the latest period of the work from accidental causes, and often from the carelessness of workmen.

Collieries.—Undoubted evidence exists of the explosion of fire damp in collieries through sparks from atmospheric electricity being led into the mine by the wire ropes of the shaft and the iron rails of the galleries. Hence the head gear of all shafts should be protected by proper lightning conductors.

Dated December 14th, 1881.

Memoranda on the Management of Portable Engines by Messrs. Ransome and Sims, of Ipswich.

Extracted from "Working Drawings and Designs," and originally published in Royal Agricultural Society's Journal.

"Preparing Engine for work.—Place the Engine as nearly dead level as possible, and in such a position that the dust from the work may not be blown upon it. The wheels should all have an even bearing on the ground, so as to prevent any rocking motion when at work.

"**Filling the Boiler.**—Care should be taken to procure water as clean as possible for the use of the Engine; water from dirty ponds or ditches should be avoided. The water must be poured into the boiler through the opening provided for that purpose (by means of an iron funnel generally furnished with the Engine), till it appears about half-way up the glass gauge-tube.

"**Glass water-gauge Apparatus.**—The Water-gauge cocks should always be tried, before the fire is lighted, to ascertain that there is no obstruction in the passages, which would prevent the water finding its proper level in the glass tube. In case the water does not appear to move freely in the tube, on opening the small cock at the bottom of the gauge, take out the two screws opposite the passages to the boiler, and insert a wire through the holes into the boiler till the water issues freely; the screw-plugs may then be put in again, and the fire lighted. Great care should be taken to prevent either of the cocks between the boiler and the glass tube becoming shut when the fire is burning and the steam up.

"**Lighting the Fire.**—The firebars must be well cleaned from dirt and clinkers before the fire is laid; a few dry chips or shavings and a small quantity of firewood should then be spread over the bars and some small coal scattered over them; a light may then be applied to the shavings from beneath the gratebars, and the fire will soon burn briskly; with some fuel it is better to place the firedoor a little way open till the coal is ignited; coal may then be put on in small quantities at a time, the firebars being kept covered to a depth not exceeding 3 inches; the fire must be clear, but the bars must not be allowed to become bare of coal in places, for the cold air will then pass through the tubes and check the formation of steam; all wet straw and damp wood should be avoided for lighting the fire. As soon as the fire is lighted, a few pails of water should be poured into the ashpan; it tends to prevent the formation of clinkers, and greatly preserves the firebars by keeping them cool; it also decreases the danger of fire in the workyards, because all the hot cinders, as they fall from the grate, are instantly extinguished; if the weather be very windy, it may be necessary to close one of the doors of the ashpan and to open the other; experience will soon point out which door should be closed.

"**Raising Steam.**—The fire as it burns up, should be kept thin and bright; the coal must never be heaped up against the tubes; too much coal should not be thrown on at a time, or it will tend to delay the production of steam; a careful Engineman will soon find out the best mode of firing with the different descriptions of coal he will be required to use.

"**Brushing out Tubes.**—If the coal is bad, or of a kind which emits a large quantity of smoke, the tubes should be well brushed out during the dinner hour; this can easily be done without dropping the fire by allowing it to burn low, and raking it into one corner of the grate. The tubes may be easily brushed out from the smokebox end. Before

commencing to light the fire in the morning the tubes must always be brushed out.

"**Safety-valve and Spring-balance.**—As soon as the water begins to boil, the safety-valve should be opened by hand and examined, to make sure that it is not obstructed in any way ; the spring-balance may then be screwed down to about 10 lbs. ; and when the steam blows off at that point it may be gradually screwed down to 45 or 50 lbs., as the steam arises. The spring-balance should on no account be left always screwed down to the full pressure when the Engine is not at work and the steam not up, because the elasticity of the spring is thus destroyed ; and it is very possible, if the Engine remains long out of use, that the valve may become set-fast, which would cause danger when the steam was next got up.

"**Oiling the Engine.**—Before starting, put a little oil into the cylinder through the cock provided for the purpose, and move the Engine round by hand, by means of the fly-wheel, to ascertain that it is all in working condition ; all the oil-cups must be filled up, and the syphon-wicks examined to make sure of their being in good condition. A little oil should be put upon the guidebars themselves, as well as into the oil-cups attached to them ; the pump-plunger and all the eccentrics must also be oiled.

"**Starting and Working the Engine.**—The piston should be placed at above the half stroke, and the regulator-valve opened gradually, the two relief cocks on the cylinder being previously opened ; after the Engine has made a few revolutions these cocks may be shut, and the regulator-valve set full open, so that the speed of the Engine may be controlled by the governors. The feed-pump should be tried as soon as the Engine is in motion, to ascertain that it is in working condition before the water has had time to diminish. To set the pump to work the suction-cock may also be opened, and shut a few times ; and the small pet-cock must also be opened and shut a few times ; if the water does not issue from the pet-cock at every stroke from the plunger, the finger should be applied so as to stop the hole in the pet-cock for a few strokes and then be taken off again ; this operation should be performed that the hole may be closed by the finger on the plunger going out of the barrel of the pump and opened on the return stroke, when the plunger is forced in again. If after repeated trials no water is thrown by the pump, and steam or hot water only issues from the cock, something is wrong with the valves, and they must be carefully examined.

Pump out of order—Valves to be examined.—The Engine must be stopped, *the cock connecting the feed-pipe to the boiler must be shut,* the covers of either or both valves may then be taken off, and the valves examined or cleaned ; *the Engine must on no account be moved round after the valve covers are put on again before the cock connecting the feed-pipe to the boiler be opened, or the pump and pipes may be seriously damaged.* The use of this cock is to enable the pump-valves to be examined when the steam is up without the danger of scalding those about the Engine.

"**Supply of Water to Boiler.**—It is desirable to have a constant supply of water always going into the boiler from the feed-pump; a little experience will soon point out to the Engineman how far the cock requires to be open to enable him to do this; the plan of shutting the feed quite off for some time, and then turning it full on, should never be adopted, for by this means the formation of steam is rendered irregular, and much fuel wasted.

"**Mode of Firing.**—The fire must be kept constantly bright and clear; the bar must be covered, but never more than 3 inches thick, and the coals must not be heaped up against the mouths of the tubes; coal must be put on the fire in small quantities, and frequently, and not all at once, and then allow the fire to burn quite low; experience will show how often the fire must be supplied with coal, as it much depends upon the quality of the coal and the amount of work that the Engine is doing.

"**Water Low in Boiler.**—There should never be less than 2 inches of water visible in the glass gauge-tube when the Engine is at work; if by accident or neglect the water should become so low as only to show about half an inch in the glass tube, the fire should instantly be dropped; by lifting the firebars, from their places by means of the tools furnished for the purpose, the burning coals will fall into the water in the ashpan and be extinguished; water should never be thrown into the firebox; the fire must on no account be again lighted until the boiler has been filled up, which may be done after the steam has gone down.

"**Bearings to be Oiled and Examined when Engine is at Work.**—The bearings and guidebars should be carefully examined from time to time to see that they are properly supplied with oil from the lubricators attached to them; it is a good plan to put a little extra oil upon the guidebars in addition to filling the lubricators upon them. Whenever the Engine is stopped, all the bearings should be felt, to make sure that they have not heated; if there be any disposition to heat, the bearings having such a tendency may be loosened a little, but they must not be too slack or it will occasion a disagreeable knocking, which is very injurious; sometimes it becomes necessary to take the top brasses quite off to free them from grit, which will cause heating in the brasses, the parts requiring most attention are the two ends of the connecting-rod and the bearings of the crank-shaft; the eccentrics, also, should be oiled occasionally when the Engine is working; the brass rings should be slackened a little if they become warm; after taking the cap off a bearing, care must be taken that on replacing it, it is not screwed down too tightly, or it will be sure to cause friction and increase the mischief sought to be avoided.

"**Preparations for moving the Engine.**—When the day's work is over, and the Engine is going to be moved to another place, the water should be run out of the boiler when the steam is quite down; *the practice of blowing all the water out of the boiler directly the fire is dropped is a very bad one,* for the sudden contraction of

the tubes caused by the rapid cooling makes them leaky, and does much mischief; *the boiler should never be refilled when hot for the same reason.* The water should never be left in the boiler, when the Engine is going to travel over a hard road; if it is merely going to be moved on soft ground for a short distance no harm will be done beyond adding greatly to the weight; care should be taken that the firebars do not shake out, and thus be lost, when the Engine is travelling. After this the funnel is folded down, and the Engine is again in a travelling condition.

"**Governor Balls.**—It is a good plan to take the levers carrying the balls off when the Engine is going to travel, as the jolting on roads is very apt to break these levers; they may be carried conveniently in the smoke-box, wrapped up in hay or shavings, to prevent injury.

"**Road Wheels to be occasionally examined.**—Before the Engine travels any great distance the road wheels are to be taken off, and the axles examined and cleaned. If the axles are much cut they should be dressed over with a smooth file to take off all roughness; they should be well greased with a mixture of oil and melted fat before going on a journey; and if the journey be long, the small screws in the naves of the wheels should be occasionally taken out, and fresh oil be poured into the axle-boxes.

"**Cleaning Engine.**—The next thing to be observed is the cleaning of the Engine, which must be conducted with great care, omitting nothing, as the slight trouble of cleaning an Engine after each day's work is amply repaid in saving the grinding of journals and brasses from an accumulation of dirt; in short, an Engine in this respect resembles very much a human being; if it is required to be in good health—so to speak—it must of necessary be kept perfectly clean. After the day's work is done the Engine should be well rubbed over with cotton waste, and all dust and grit should be removed, also all superfluous oil which may have accumulated during working; the chimney should be lowered down and the Engine be covered over with the tarpaulin furnished for that purpose; the Engine should always be carefully covered up when travelling to prevent the working parts becoming injured by dust or mud.

"**Washing out Boiler.**—The boiler must be well washed out and cleansed after about twelve or fourteen days' working; to do this the brass plugs and mud doors round the bottom of the outside shell of the firebox must be taken out, the water must be poured freely into the boiler through the opening where water is poured in, the mud and scales being at the same time loosened and pulled out with a small iron rod, the end of which should be made like a hoe; at the same time the plug beneath the tubes in the smoke-box should be taken out and the manhole-cover be lifted off, a long rod being pushed backwards and forwards through the hole under the tubes, so as to loosen the dirt and sediment. Water should be poured into the manhole plentifully, so as to wash out all that may be collected in

the boiler through the various mudholes, which should all be open during this operation. On again putting in the brass plugs, be careful not to cross the threads; they may be entered with the fingers only, and not screwed up with a spanner until they have been screwed several turns by hand.

"**Preparing the Engine for lying out of work for a considerable time.**—If the Engine is not going to be used for a length of time (say a month), the cylinder-cover should be taken off, and the cylinder well rubbed dry, and oiled; the fly-wheel should then be turned round a few times by hand to ensure every part of the piston and slide becoming well covered with oil; the cylinder cover may then be put on again; the joint only requires a little redlead cement to be spread around it, but the redlead must not be so placed as to squeeze into the cylinder itself when the cover is screwed up; care must be taken to screw the bolts up very equally. The whole of the bright work of the Engine must be well dressed over with a mixture of white-lead and hot tallow, put on with a painter's brush. The packings from the piston-rod, slide-rod, and pump-plunger should be taken out, for they injure the rods by causing corrosion to take place from the moisture of hemp packing.

"**Packing the Engine.**—This operation cannot easily be described, and must be seen to be comprehended thoroughly; the Engineman, who is sent from the works with the Engine, will probably instruct the person who is about to take charge of the Engine how to do the packing; but this and many other things require practice to do them properly. None but the best white spun-yarn and white hemp must be used for packing, and it must be quite free from all gritty particles. The packing, before being put into the stuffing-boxes, must be well soaked in hot tallow.

"**Oil for Engine.**—Neat's foot or sperm oil should be used; but if this cannot be procured, olive or castor oil will answer the purpose. Hot tallow should never be poured into the cylinder, for much dirt is thereby introduced, which will cut and injure the piston and cylinder.

"**Small Repairs.**—The parts that will require repairing most frequently are the brasses of the connecting-rod and crank-shaft; the guidebars also occasionally require adjusting; but all these things should be done by an Engineer who is accustomed to the work, and the file and chisel must never be used by the Engineman, or more harm than good will be done."

Lastly, in giving a few instructions for slight repairs we presume that the attendant is capable of using the files to a small extent; if not, for some of the repairs, such as re-fitting the brasses, it will be necessary to procure a mechanic. Should there be any leakage at any of the glands or stuffing-boxes, they may be tightened by screwing up; if, however, they have been frequently screwed up, they will require to be refilled with fresh packing, which is done by introducing into the stuffing-box a quantity of hemp or spun-yarn of the finest quality, which is plaited into a square or flat rope, capable of exactly filling the box sideways, inserting as many coils along with tallow as wil

fill it nearly full, leaving as much room as will admit of the gland entering, which must be screwed up equally on each stud, avoiding all jamming. All the glands on the Engine are treated in the same manner except the gauge glass, which is packed with India rubber washers made expressly for the purpose; if these cannot be procured, a little cotton wick should be inserted in the same manner as the hemp; in the glands above noted, if the connecting-rod or crank-shaft brasses are loose, which may be easily ascertained from the knocking noise made by the part, it is necessary to remove the strap by withdrawing the gib and cotter and taking out the brasses, apply them to the journal to which they belong with the hand, when the exact amount of looseness or play will be ascertained, which must be taken off the butting surface to allow the brasses to come together. If the brasses are bearing on the journals throughout their whole circumference, it is advisable to ease them at the sides to the extent of one-sixth the circumference, leaving two-thirds bearing top and bottom. This being done, the brasses may be put in the places and the cotter driven up sufficiently tight to prevent knocking and sufficiently slack to prevent heating; to do this part of repairing, however, will require an attendant having a slight knowledge of the construction of Engines.

General Remarks.—The more care and attention the Engine receives the longer it will work without extensive repairs. Very frequently great damage is done, and heavy expense incurred, through the carelessness and ignorance of the person who acts as Engineman. Wood should never, if possible, be used as a fuel when the Engine is at work near timber or thatched sheds, on account of the great quantity of ignited pieces thrown out of the top of the funnel by the steamblast. All tools and spanners must always be kept in the tool box with the Engines ready for use, and every thing should be kept in its place.

Good stoking consists, first, in preparing and selecting the coals so as to be of the proper size fitted for the purpose; and, second, supplying these coals in a regular methodical way to the interior of the furnace. First, as to the condition of the coals. These should be broken carefully in small pieces. Mr. Armstrong, a modern authority on Boiler Engineering, says:—"See that no coal is left in the heap ready for going on, bigger than a man's fist, and that the very small coal, or slack, is wetted or at least damp." As to the second point, the mode of supplying the coal to the furnace. This has been summed up in the following sentence:—Fire thinly, fire frequently, and fire regularly. Watt long ago saw the value of the thin mode of firing. "The oftener," he says, "you fire, and the thinner, the better. The fire should be kept an equal thickness, and free from open places or holes, which are extremely prejudical, and should be filled up as soon as they appear."

Bridges.

B. B. and C. I. R.—Most of these bridges are of Warren's Girders 62½′ long, 7¾′ deep, clear span 60′; weight 24⅝ tons per

span; cost Rs. 190 per ton; tested to 1¼ tons per foot run. Cost of screwing cast-iron piles, including erection, fitting and painting, Rs. 9 per running foot. Cast of erecting, fitting girders, including timbers, planking and painting, Rs. 30 per ton.

Erection of Iron Girders.—The Chief Engineer, G. I. P. Railway, gives the average cost of erection of ironwork of girders of 60 feet, 80 feet, and 100 feet spans at Rs. 50 per ton.

Flooring for Road Bridges.—There is no flooring for wooden bridges of any sort better than round uncut Teak "Bullies" *well seasoned* with bark, removed, placed transversely, not touching each other, the intervals filled with clean round pebbles, and over them concrete brought to the proper barrelled shape, on which is laid the gravel or metal road surface. The rafters not to be dammered. The rafters of this sort on the Sungum Bridge at Poona put down more than 20 years ago were perfectly sound when removed for the construction of the new bridge.

Wing Walls.—There is nothing destroys the appearance of a road more than having the coping of the wing walls of bridges and drains either higher or lower or not in the same plane with the slope of the bank; and yet it is a point on which Overseers are remarkably careless. Insist on the coping of the wing wall being perfectly flush in the same plane with the slope of the bank, and the junction of the road and bridge will always look well finished.

Sand Boxes.—Up to 30 feet span it is not necessary to use sand boxes, but strong double canvas sand bags answer equally well. When it is necessary to strike the centre, slit the bags with a knife, and the sand escapes as required.

Arch Quoins.—It is a common practice to make arch quoins the thickness of 2 or 3 courses of the arch sheeting, the result being that, when the arch settles, the quoins separate from the sheeting. The compiler can state that he has seen hundreds of bridges and drains in this country where this has occurred, and many cases in which the ashlar arch quoins have had to be removed, and new quoins of the same thickness as the sheeting put in. Except, therefore, in bridges where the faces of the arch are seen and an architectural appearance is required, the quoins should invariably be of the same thickness as the sheeting. It is simply weakening the bridge at a useless expense to put ashlar quoins with fine joints to rubble sheeting.

This separation between the arch quoins and sheeting also frequently results from the difference of dressing in the beds of the sheeting and quoins, and of the thickness of joints: also to the want of *bond* between quoins and sheeting. This latter may be modified by the introduction of Hoop iron bond.

Pile Driving.

Without a Pile-driving Engine. Set an iron rod 2 inches in diameter and 7 feet or 8 feet long about 1 foot into the centre of the head of each pile truly parallel to the length. Up and down this guide rod is

worked a wooden monkey about 9½ inches diameter and 3 feet long provided with 4 handles of ¾ inch iron secured by wood screws to the block under 2-inch iron rings shrunk on at either end. Down the centre of the monkey is a 2½-inch hole to allow it to slide freely up and down the guide rod. The monkey is worked up and down by men who stand on a platform fixed to the pile.

In calculating the effects of a monkey (ram) in driving a pile, an approximate value may be obtained by assuming that the impact or force of the blow (in foot-lbs.) $= w\sqrt{29h}$ where—

w = Weight of ram in lbs.
g = 32·2 feet.
h = fall of ram in feet.

Pipe Laying.

Weight and thickness per 2 yards of iron piping—

Diameter.	Thickness.	Weight per yard. Cwt.	qrs.	lbs.
3″	⅜″ full	0	1	16
4″	⅜″ „	0	2	2
5″	7/16″ „	0	2	23
6″	½″ bare	0	3	19
7″	½″ „	1	0	9
8″	½″ „	1	1	4
9″	9/16″	1	2	8
10″	9/16″	1	3	0
11″	9/16″ full	2	0	4
12″	⅝″ „	2	1	14
15″	11/16″ bare	3	0	7
18″	11/16″	3	3	9
21″	¾″	4	3	0
24″	⅞″	6	1	0
27″	1″	8	0	7
30″	1 1/16″	9	2	0
33″	1⅛″	11	0	0
36″	1⅛″	12	0	0
42″	1⅛″ full	14	1	9
48″	1¼″	18	1	0

A safe estimate of amount of lead required for laying socket pipes is ½ circumference in inches, equal to number of lbs. of lead. Pipes with turned or bored joints are, however, more used now than those with socket ends.

Cast-iron pipes, for 99 feet, or 11 pipes in 9 feet lengths 2 feet below surface.

Labour and Materials.

Labourers 20.
Lead 11 × 12 lbs. = 132 lbs.
Hemp 11 × ½ „ = 5½ „
Charcoal = 20 „

8-inch pipes.

Labourers 20.			
Lead 11	×	$8\frac{1}{2}$ lbs.	$= 93\frac{1}{2}$ lbs.
Hemp 11	×	$\frac{1}{3}$ lb.	$= 3\frac{2}{3}$ „
Charcoal			$= 15$ „

6-inch pipes.

Labourers 20.			
Lead 11	×	7 lbs.	$= 77$ lbs.
Hemp 11	×	$\frac{1}{4}$ lb.	$= 2\frac{3}{4}$ „
Charcoal			$= 12$ „

3-inch pipes.

Labourers 20.			
Lead 11	×	2·5 lbs.	$= 27\frac{1}{2}$ lbs.
Hemp 11	×	$\frac{1}{6}$ „	$= 1\frac{5}{6}$ „
Charcoal			$= 8$ „

Note.—Actual rates from Pandharpur Water Works.

Earthenware Pipes.—12 inches diameter 2 feet below surface 10 pipes or 20 feet in length laid with oil cement.

Labour—	
Excavation	3
Laying	$1\frac{1}{2}$
Cement	2
	$6\frac{1}{2}$
Materials—	
Pipes	10
Lime	20 lbs.
Oil	4 „

Prices in Bombay.

For 2 feet lengths.

	Rs.	a.	
6 inches	1	6	each length.
9 „	2	4	„
12 „	4	0	„

Solution for coating Iron Pipes, &c.

30 gallons	Coal Tar.
30 lbs.	Fresh slaked lime.
6 „	Tallow.
3 „	Lamp black.
$1\frac{1}{2}$ „	Resin.

Mix well, boil for twenty minutes, and lay on hot.

Pumping.

Gwynne's Centrifugal Pumps.—The following may be taken as a fair estimate of the discharge and necessary power required to drive the following sizes of pumps :—A 6-inch pump will discharge 700 gallons per minute worked by a 6-H. P. Engine. A 7-inch, 900 gallons per minute worked by an 8-H. P. Engine. An 8-inch, 1,100 gallons per minute worked by an 10-H. P. Engine. The smaller sizes worked by hand and bullock power are not found to be effective.

Cost of filling Kalyán tank (Railway) by *steam* power is Rs. 2-10 per 9,000 gallons, or 4 annas 8 pies per 1,000 gallons ; Bhándup tank by *hand* power Rs. 3 per 12,550 gallons, or 3 annas 10 pies per 1,000 gallons.

Boring.

The ordinary boring apparatus consists of a succession of iron rods from 10 feet to 20 feet in length, 1 inch square in section joined by screw threads ; the boring tool is attached to the lowest rod. The screw joint Fig. 1 has the disadvantage of coming undone when from any circumstance it becomes necessary to turn the rod in the opposite direction to that in which the thread runs. Another joint which has not this disadvantage is shown in Fig. 2.

The augur Fig. 3 is similar to a carpenter's. It is used when boring in earth, clay, or firm sand. The mud shell Fig. 4 consists of a cylinder of a strong sheet iron with a diaphragm across it having a hole in the centre closed by a valve opening upwards or by a ball It will loosen and raise quicksand, mud, and earth of too loose a nature to be removed by the ordinary augur. The chisel Fig. 6 is sometimes made of the same shape as the miner's jumper or with three edges radiating from the centre as shown in Fig. 5. It is used for piercing rocks, stones, &c., in a similar manner to a miner's jumper by raising it some distance and letting it drop, gradually turning it round after each blow. The pounded rock is brought to the surface by the augur or by a long spoon. Another chisel is shown in Fig. 7.

The worm screw Fig. 8 is used for catching up and removing small stones or any other foreign matter which may have tumbled down the boring, or for raising a broken rod, &c. The tube drawer Fig. 9 is used for drawing such tubes as have to be raised or have been badly put down. The conical bell Fig. 10 is for recovering any length of boring rods which may have dropt down.

In military boring operations, when materials and timber may be scarce, it is usual to work without a scaffolding, using a triangle gyn to raise the rods and sinking a pit 6′ deep 6′ in diameter at top and 4′ at the bottom for the men who turn the rods to work in (Fig. 13). This pit having been sunk and the gyn erected with its summit directly over the intended boring, a pully 1′ in diameter, called a rigger, must be fastened to the gyn, to take the rope for elevating the boring rod. A frame 1′ square, called an augur board, having two flaps, is sunk in the bottom of the floor of the pit so as to prevent any loose stuff from

Boring Tools. Plate XXVII.

Fig. I. Joints of Rods. Fig. II.

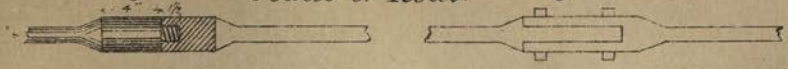


Fig. III. Auger Mud Shell. Fig. IV.

C h i s e l s

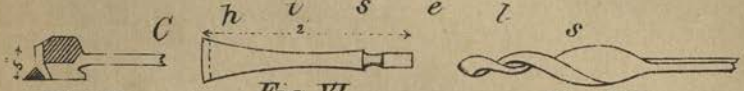


Fig. V. Fig. VI. Fig. VII.

Rod and Tube Drawers.

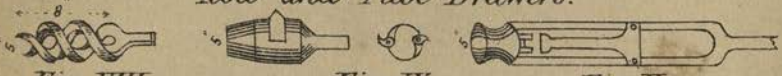


Fig. VIII. Fig. IX. Fig. X.

Fig. XI.

Fig. XII. Double Lever

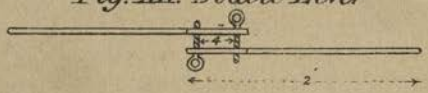
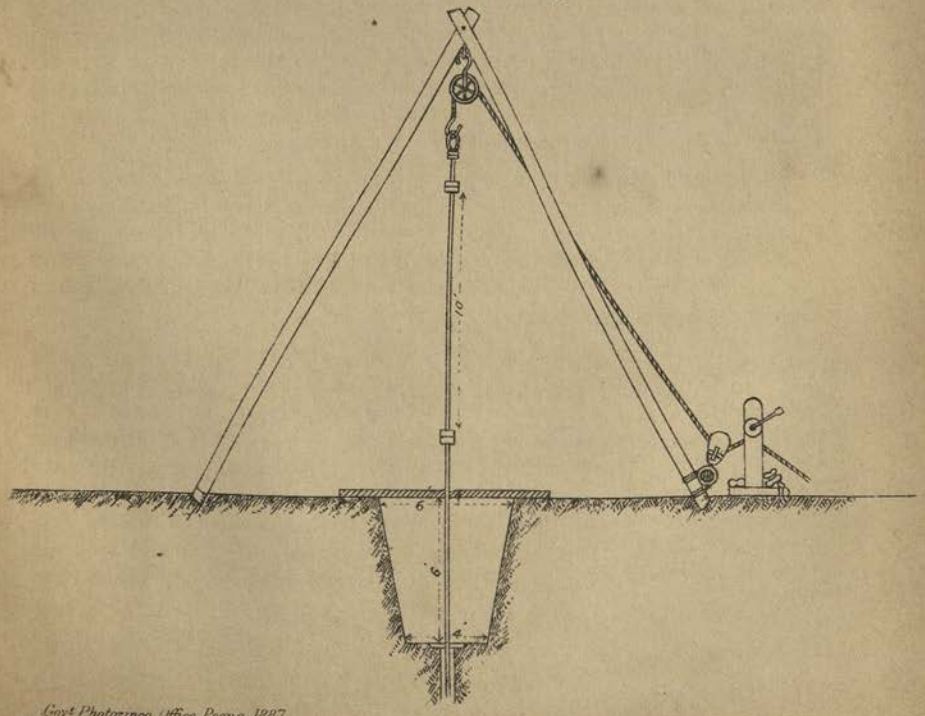


Fig. XIII.
Section of Boring.



Govt Photozinco Office, Poona, 1887

tumbling down the boring. There is a hole of 2″ in diameter between the flaps for passing the boring rods through. A spar is lashed to 2 legs of the gyn close to the ground, to which a snatch-block is fastened for taking the fall to the windlass, which is placed close to the spar, and weighted down with sand bags, &c.

The fall being rove through the block, the lower end is attached to a short end (about 2′) of rod having a swivel at the top which allows the rod to turn round without twisting the rope. Next a rod is screwed on, and the fall being tightened, the rod is raised vertically into its position over the intended boring, and passed through a 3″ hole in the centre of a plank laid across the pit.

Two men descend into the pit and there attach the boring tool to be used, screwing it well home by means of the double lever shown in Fig. 12 which they afterwards use for turning the rods, shifting it up the rod as the boring progresses. The men above, cover over the pit completely with planks, and slip the fourhandled lever on to the rod. The men in the pit open the flaps of the augur board, and lower the tool on to the ground, and man their double-handed lever, while the men above work their four-handed one, walking round with the sun. In this way the boring is continued, the tool being occasionally raised into the pit to clear it of earth or to change it, additional lengths of rod being added as required. If the boring is to be carried to a considerable length, a scaffolding in a deeper pit will be advantageous, to enable the rods to be unscrewed in sections equal in length to the depth of the pit, whereas with a gyn and a 6 feet pit each joint must be separated.

The chisel is worked by the men simply hauling on the rope and suddenly letting it go. If the weight becomes too great to be thus raised, it can be lifted by the windlass, the man who hauls on the fall simply slacking it when the chisel is raised sufficiently, and allowing the turns to slip round the barrel; he should only pay out enough rope to allow the chisel to fall the depth of its stroke: if too much rope be paid out, the head of the rod wabbles about, and the rods get bent.

When the strata through which the boring passes are firm, the smallness of its diameter will render needless the taking of any precautions to prevent the sides from falling in: but if the boring passes through strata of quicksand, marshy earth, &c., a casing of pipes must be provided.

The pipes generally used are of wrought-iron from 12 to 15 feet long and of successive diameters, from 3 inches upwards, so as to pass one within the other. They are provided with bayonet joints, by which they are united together. The largest pipes are first placed in the boring, successive lengths being added at the top until the required length is got in, and forced down if necessary by a monkey or small pile engine, acting on a block of elm fitting in the head of the pipe. When the resistance of the earth prevents the pipes being driven any further, one of which the exterior diameter is exactly equal to the interior diameter of the pipe already placed, is lowered down, the boring

for it being made by tools of proper diameter. Successive series of pipes are added as required, until the diameter of the hole is so much restricted as to prevent any further boring. If water be not yet met with, the only thing is to withdraw all the pipes, and commence from the top with pipes of larger diameter.

Samples of the various strata through which the boring passes should be preserved, their thickness and any other information likely to prove useful being noted.

Too great precautions cannot be taken to prevent the breaking of the boring rods, which is the most troublesome and expensive accident that can occur. When the boring rods, from their great length, become too heavy to be lifted and allowed to drop with safety, a portion of their weight may be taken by means of a counterpoise. In America the boring is generally made entirely by jumping, one length of rod only being used next the chisel, the remainder of the rod being replaced by rope.

Knotting and Splicing.

The size of rope is denoted by its circumference in inches, and its length is always given in fathoms.

When a rope is passed through a block, it is said to be *rove;* if one end is made fast, that end is called the *standing part,* the other end the *running end,* and the end of the rope to which the power is applied *the fall.*

In the plates the points of the running ends are shown *whipped,* and the direction in which the power is applied is denoted by an arrow.

In uncoiling a new coil of rope, pass the end which is at the core through the core to the opposite side, and draw it out, when the turns will run out without kinking.

Thumb or Overhand Knot.—Grasping the end of the rope with the right hand, and the standing part in the left, pass the end of the rope over the standing part up through the bight thus formed; haul taut, and the knot is complete. This is the simplest kind of knot, and is used to prevent ropes running through blocks when rove, &c. (Fig. 2.)

Figure of 8 Knot.—Holding the rope, as in the last paragraph, pass the end of the rope under, round and over the standing part, then upwards through the bight thus formed. This knot is used for much the same purpose as the last. (Fig. 3.)

Reef Knot.—Holding one end in each hand, ends to the front, lay the ends of the two ropes to be joined across one another, the left hand rope over the right, and take it once completely round that held in the right hand. Turn the original left hand end back in the direction of and alongside its standing part, and take the original right hand end over the double, up through the loop, and haul taut. The standing

Knots &c. Plate XXVIII.

Fig. I. Coiling a Rope

Fig. II. Thumb.

Fig. III. Figure of 8.

Fig. IV. Reef

Fig. V. Granny

Fig. VI. Draw

Fig. VII Single Sheet Bend.

Fig. VIII Round Turn and Two Half Hitches

Fig. IX. Rolling Bend

Fig. X. Fisherman's Bend

Fig. XI. Double Sheet Bend

Fig. XV. Sheep Shank

Fig. XII. Clove

Fig. XIII. Hitch

Fig. XIV. ch

Fig. XVI. Commencement of Bowline.

Fig. XVII. Bowline

Fig. XVIII. Running Bowline

Fig. XIX. Bowline on a Bight.

Fig. XX. Timber Hitch.

Fig. XXI. Carrick Bend

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and running parts of each rope must pass through the loop of the other part in the same direction (Fig. 4): if they pass in the opposite direction, as in Fig. 5, the knot is what is termed a granny, and cannot be undone when tightened up with the same ease that a reef knot can. A reef knot can be upset, and the ends pulled out, by taking one end of the rope and its standing part, and pulling them in opposite directions.

Draw Knot.—This knot is the same as a reef knot, with the exception that a double of the original left hand end is laid alongside its own standing part, thus forming a loop, and the right hand end is taken over the double, and the loop formed by the double as in the above knot. (Fig. 6.)

Single Sheet Bend.—Take a bight or double at the end of one rope, holding it in the left hand, and pass the end of the other rope held in the right hand up through the bight, down on one side under and up over the bight and under its own standing end (Fig. 7). It is used for joining two anchor cables together.

Double Sheet Bend.—When greater security is required, *a double sheet bend* is used, in which the running end is passed twice round the bight and under its own standing end each time. (Fig. 11.)

Two Half Hitches.—With the end of the rope in the right hand and the standing part in the left, pass the end of the rope round its standing part, and up through the bight, thus forming one-half hitch; two of these alongside of one another complete the knot; in Fig. 8 this knot is represented on the standing part of rope passed round, and made fast to a spar, but it should never be used for hoisting a spar. The end may be lashed down to the standing part by a piece of spun yarn, which adds to its security, and prevents the end from slipping.

Round Turn and Two Half Hitches.—This knot is the same as the last, with the exception that a complete turn is taken round the spar or other object to which the rope is to be fastened, and the half hitches taken afterwards round the standing part (Fig. 9); this knot is sometimes called *a rolling bend.*

Fisherman's Bend.—Two complete turns are taken round the spar or other object to which the rope is to be fastened, and the end passed over the standing part, through the two turns next the spar over its own part, thus forming one-half hitch, and the second half hitch taken round the standing part alone. It is used in pontooning, to fasten the cables to the rings of the anchors (Fig. 10).

Sheep Shank.—This knot is used for shortening a rope, the ends of which are made fast; the rope is laid up in 3 parts (Fig. 15) and a hitch taken over each bight with the standing and running parts, respectively, of the rope, and jammed taut.

Clove Hitch.—When it is desired to secure a rope to the end of a spar, this knot can be made first, and the loop so formed passed over the end of the spar.

To make this knot, make two loops with the running end of the rope (Fig. 12); place the last made loop over the other one (Fig. 13), and slip the double loop so formed over the end of the spar, &c. (Fig. 14.)

When a rope has to be secured to a spar, over the end of which the knot cannot be slipped, pass the end over and round the spar, bring it up to the left of the standing part, and again down and round the spar, to the right of the first turn, and bring the end up between the spar the last turn, and the standing part (Fig. 14). When used in lashing spars, the end should be twisted round the standing part as in the figure. As this knot is one of the most useful and most frequently required, men should be practised in making it in various positions.

Bowline.—Holding the standing part of the rope in the left hand, with the right hand lay the end over the standing part pointing to the left; keeping the end in place with the right hand, make a loop with the standing part over the end, pass the end under the standing part, and finally down through the loop, previously made, and haul taut the end and the double of the knot together (Figs. 16, 17).

Bowline on a Bight.—Fig. 19 illustrates this knot. Double the rope, and lay the loop held in the right hand over the two ends held in the left hand; with the left hand make a loop over the doubled end, and opening out the doubled end, bring it upwards over the hole of the knot, and haul the double taut (Fig. 19).

Timber Hitch.—Pass the end of the rope over and round the spar, &c., and round its own standing part close to the spar. Then twist it two or three times back round itself, and haul the fall taut, thus jamming the twisted end against the spar. This knot can be easily undone when the strain is taken off the fall, and is found to be really secure for lifting spars, &c., as when well made it will not slip (Fig. 20).

Carrick Bend.—A Carrick Bend is used for joining two cables or two ropes to make 4 guys for the head of a spar. Holding one of the cables to be joined in the left hand make a loop on the end of it, passing the end under the standing part away from the persons making the knot. With the right hand pass the end of the other cable across the loop under the other end over the other standing part, up through the original loop over its own standing part, and finally down through the loop and haul taut. If either of the cables (Fig. 21) be traced, it will be seen that it passes alternately over and under each rope that it crosses.

Cat's Paw.—Lay the end over the standing part of a rope, thus forming a bight, and secure the two parts together by a bit of seizing; then lay hold of the bight with one hand on each side, twisting the hands inwards in opposite directions two or three times: clap the two bights together, and hook on the tackle, &c., as required. This knot may be used as a pair of slings for shipping casks, &c. (Fig. 22).

Stopper Hitch.—Take one turn round with the stopper round the rope to be stoppered, and then a second over-riding the turn previously made, in the direction in which the power is applied, and bring the end over its own standing part and fasten off with two half hitches round the cable, on the opposite side of the standing part of the stopper to that on which the round turns were taken (Fig. 23).

Knots & Tackles.

Plate XXIX.

Fig. XXII.

Cat's Paw

Fig. XXIII.

Stopper Hitch

Fig. XXIV.

Slip Knot

Fig. XXV.

Commencing a Short Splice.

Fig. XXVI.

Fig. XXVII.

Fig. XXVIII.

Eye Splice

Fig. XXIX.

Fig. XXX.

Wall Knot

Fig. XXXI.

Crowning a Wall Knot

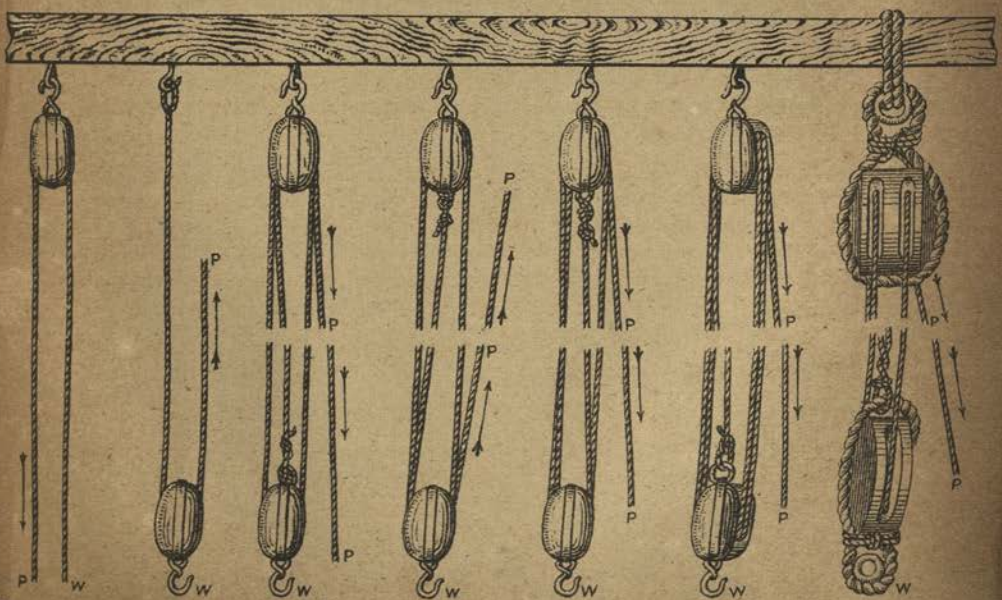

Fig. XXXII. Fig. XXXIII. Fig. XXXIV. Fig. XXXV. Fig. XXXVI. Fig. XXXVII. Fig. XXXVIII.

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Slip Knot or Hangman's Knot.—Take a bight on the end of a rope, and grasp it in the left hand, the bight towards the right. With the end take 4 round turns round the double of the bight, working from left to right, and pass the end through these 4 turns next to the standing part, and haul taut (Fig. 24).

Wall Knot.—This knot is a neat way of fastening off a rope to prevent its unstanding. Unlay the end of the rope (Fig. 29), and hold it with left hand end upwards. Lay the end of the nearest strand, *a*, across the front of the rope end to the right, so as to form a loop to the left. Bring the next strand on the right over and round the end of *a* to the rear of the rope, forming a loop with its end to the left; similarly pass the end of the third strand over the end of "*b*", and round it to the front through the loop in *a*, haul taut each strand and the knot will appear as in (Fig. 30).

To crown this knot, take the end of the front strand, *a*, pass it over the head of the knot, and down the rear of the rope between the other two strands, leaving a loop at the top of the knot to the front (Fig. 31). Take the next strand to the right *b*, and pass it round the rear of the loop *a*, and over the knot between the loop and the 3rd strand *c*, and down the front of the rope. Pass the third strand *c* over *b*, where it crosses the loop at the head of the knot, and through the loop in *a*, and hault taut.

Blocks.—For the purpose of changing the directions of ropes, gaining power, &c., blocks are used. They are usually made of wood and are called single, double, or treble, according to the number of sheaves contained, which being made of metal or hard wood, revolve with but slight friction on a central pin. The block is surrounded by a strop of rope or iron, by means of which it can be lashed or made fast as required; the sizes of blocks are designative by their length usually expressed in inches.

Tackles.—Figs. 22 to 38 show the various combinations of blocks most commonly used for forming tackles with falls rove ready for use where W is the weight to be moved and P the power applied.

Fig. 32 a single moveable block, which gives no increase of power, but merely a change of direction. It is often called a whip, and for this purpose a snatch block (*i. e.* a block with a moveable strop to admit a rope without the necessity of passing its end through the block) is often used.

Fig. 33 a single moveable block, when $W = 2\ P$.

Fig. 34 a gun tackle consisting of a fixed double and moveable single block where $W = 3\ P$.

Fig. 35 with a fixed single and moveable double when $W = 4\ P$.

Fig. 36 a luff tackle with 2 double blocks, the standing ends being attached to the fixed block when $W = 4\ P$.

Fig. 37 a gyn tackle with a fixed treble and a moveable double block where $W = 5\ P$.

Fig. 38 a gun tackle of large blocks with thimbles fitted instead of hooks.

The standing end of the rope is never fixed to the block with the greater number of sheaves; the weight any system of 2 blocks will lift is formed by multiplying the power by the number of ropes at the moveable block including the standing end if fixed to it. The strops of blocks must be strong enough to withstand the greatest strain, which is equal to the power multiplied by the greatest number of ropes at either block.

To form a pair of Temporary Sheers.—The two spars for the sheers of equal length are laid alongside each other with their butts together on the ground, the parts below where the lashing is to be, resting on a short spar. A clove hitch is then made round one spar and the lashing taken loosely 8 or 9 times round the two spars above it without riding. A couple of frapping turns are then taken between the spars round the lashing, and finished off with a clove hitch above the round turns on the other spar. It will then appear as in Fig. 1.

The butts of the spars are then opened out, and a sling passed over the fork of the spars to which the block is hooked or lashed. Fore and back guys are then made fast with clove hitches to the tips of the spars, so arranged as to draw their heads together; when the strain comes on them foot ropes are secured to the butts of the spars by pickets, and the sheers are ready for raising (Fig. 2).

To form a Gyn or Tripod Trestle.—The distance from the butts at which the centre of the lashing is to be is marked on each spar. Two of the spars are then laid parallel to each other, rather farther apart than their own diameter, with their tips resting on piece of skidding, and the 3rd spar is laid between them, with its butt in the opposite direction, so that the marks on the 3 spars may be in line. A clove hitch is then made on one spar, and the lashing taken over and under the spars loosely 8 or 9 times; the lashing will then appear as in Fig. 3. A couple of frapping turns are then taken between each pair of spars in succession round the lashing and finished off with a clove hitch in one of the spars; the lashing will then appear as in Fig. 4. A sting is then passed over the lashing and the gyn is ready for raising.

To lash a Transom to an upright Spar (see Figs. 5, 6, and 7).—In the description the transom is supposed to be in front of the upright. A clove hitch is made round the upright below the position of the transom, the lashing brought under the transom, up in front of it, horizontally behind the upright, down in front of the transom and back behind the upright, below the clove hitch, and so on following round, keeping outside of, and not riding over the turns already made. Six turns or more will be required. A couple of frapping turns are then taken between the spars round the lashing, binding the whole firmly together, and the lashing is finished off with clove hitch either round one of the spars or any part of the lashing through which the rope can be passed. The lashing must be well beaten with a handspike or pick handle, to tighten it up.

Plate XXX.

Lashings of Spars.

Fig. I.

Fig. II.

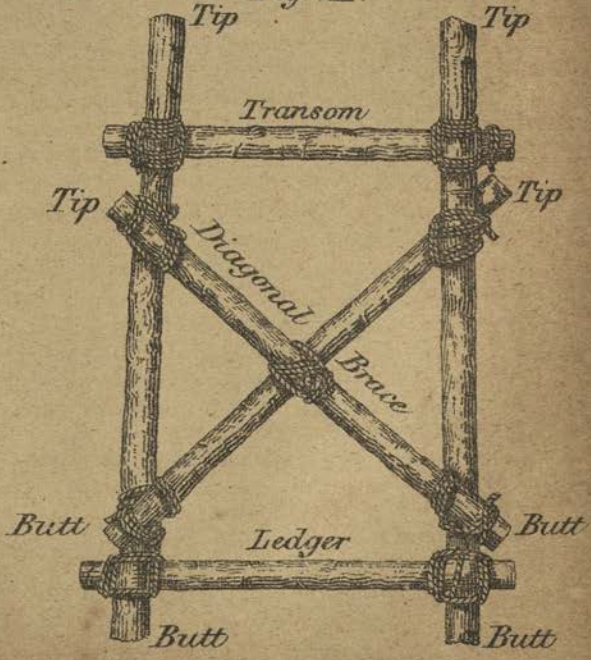
Fig. III.

Fig. V.

Fig. VI.

Fig. IV.

Fig. VII.



Govt Photozinco Office, Howrah, 1887.

CONCRETE ARCHED ROOFING.*

Class of building in which used.

A considerable number of police quarters, chowras, and other small buildings in the Kaira Division have been roofed with concrete arching at a cost not exceeding that of ordinary tiled roofing, and with a large saving in maintenance charges.

Span.

The limit of span hitherto has been (10) ten feet, and in order to keep within this, larger spaces are divided into spans of 10 feet or less, by means of wrought-iron beams. Double-headed railway rails (60 to 75 lbs. per yard) make cheap and useful girders when small bearings can be arranged for, and in other cases rolled iron beams of suitable section have been adopted.

Rise of arches.

A rise of 2 inches to the foot is allowed for spans of 10 feet and under, if lime concrete is used. For Portland Cement Concrete this may be reduced, and for 6 feet arches in cement one inch rise per foot of span has been found sufficient.

Thickness of arches.

For 10 feet arches 6″ of good lime concrete is enough, though occasionally a thickness of 7½ inches has been given. For smaller arches 4½ to 6 inches is required, though less than 6″ should only be given when cement is used.

Abutments.

Either the outer walls carrying end arches must be made strong enough to act as abutment, or the horizontal thrust of end arches must be taken either by L iron and tie rods as shown in the accompanying Plates, or by some other similar arrangement. In a series of arches this tieing is only necessary for the two end spans, and the ties may be either simple iron rods, or if greater stiffness is required, double bars with timber between as explained in sketches. The ties must be fixed to the angle irons with properly designed joints, which will vary according to circumstances.

Intermediate arches.

In the case of a series of arches on cross walling or girders, either of the methods shown in explanatory sketches may be adopted, and water can be carried off roofs by sloping the backing over haunches so as to form gutters.

Centring.

Centring may be either fixed, or on sand bags or wedges in order to facilitate removal. The centrings should not be removed in less than 20 days, and it is better to allow a clear month. Ordinary bridge centrings are used and cost in Kaira about Rs. 10 to Rs. 12-8-0 per 100 superficial feet. The curve of the intrados is rendered true by means of a layer of plaster, or accurately shaped laggings may be used and covered with sheet zinc if the number of arches is sufficient to admit of this without undue cost.

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* Communicated by T. Little, Esquire, Executive Engineer, Kaira District.

Concrete. Should be composed of—

(1) Thoroughly burnt lime of good quality.
(2) Sharp clean sand.
(3) An aggregate which may be either broken stone, ballast, kankar, or broken brick.

Ballast or porous stone forms the best aggregate, and brick is not recommended if any better material can be obtained, as it is liable to pulverization in ramming. In the Kaira Division the most satisfactory results have been obtained by mixing the lime and sand into good mortar similar to that used in building, and composed of 1 to 2 parts of the latter to one of the former, the precise proportion depending on the quality of lime. To one measure of this mixed mortar is added 2 to 3 measures of the aggregate, which should be of a size to pass through a ring 1″ in diameter; all dust to be rejected, and the material to be clean and wet at the time of mixing. The mixing to be done very thoroughly on platforms and not more than ½ to ¾ of a cubic yard to be mixed at one time on one platform. If the lime is very fat in quality it may be desirable to use a proportion of soorkhi with the sand.

Spreading concrete. The centring having been prepared, the rough plastered or other surface should be wetted, and should then have pounded brick sprinkled over it to a depth of about ⅛ to 1/12 of an inch, and on this half an inch of lime plaster to be spread, and then the concrete, the plaster and the concrete to be carried on together, the former being slightly in advance of the latter. The effect of this is that the concrete adheres to the plaster which forms the under side of it, and the pounded brick is the dividing layer, some of which remains on the centring below and the balance adheres to the arch above. The spreading and ramming to go on from both haunches simultaneously towards the crown. If the arch is not more than 6 inches in thickness, it should be completed in one layer and in one day, but if over 6 inches it may be made in two or more layers, each layer to be finished up in the day, and the top of lower layer to be roughened before the upper is added. Very thorough ramming is necessary at the time of spreading, in order to get the work solid and compact, and the newly formed arches should be kept wet by means of a layer of grass, straw, or leaves, which should be watered each day for a month.

Expansion. In a very long series of arches it may be desirable to allow for expansion, and this can be done where required by inserting an inch plank at back of arch near springing. The plank to be removed immediately the work has set sufficiently to admit of this, and the space should be grouted after an interval of two or three days. It is seldom that this precaution will be required in arches with lime concrete.

Plastering. Arches to be roughly plastered below, and to be plastered above with good lime plaster similar to that used for flat roofs, and a wash or thin layer of cement may be given over the plaster if found desirable, but this is not usually required.

These walls may be built solid, or where ventilation is required the tympanum portions may be filled in with tile pipes laid with an upward slope so that water may run off outside. All such walls running up to intrados of arches should be carried out after the centring has been removed and the arch has fully settled, for otherwise the walls would lead to cracks.

Front, rear and partition walls.

Verandahs may be of planking or tiled, but there should be a string course just above top of tiles or planking to prevent water running down face walls.

Verandahs.

This filling may be of ordinary concrete of good quality, and the upper surface to be plastered over in the same manner as described for extrados of arches.

Filling over arches at haunches.

Cost. The cost of concrete arching of the description referred to, excluding iron work but including centring and plastering per 100 superficial feet (in the Kaira Division), is found to be nearly as shown in margin.

	Rs.	Rs.
Lime concrete 6" in thickness for 100 superficial feet of roof	10 to	13
Centring	10 to	13
Plastering above and below	5 to	7
Contingencies	1 to	2
Total for 100 superficial feet ...	26 to	35

Concrete roofing is measured flush from outside to outside of walling, while in tiled roofing the eaves must be added plus the extra for slopes, and for small buildings it will be found that 100 superficial feet of flat concrete roofing would be represented by from 130 to 150, superficial feet of tiled roofing.

Mode of measuring.

Double tiled roofing with teak framing for small spans costs Rs. 30 to 40 per 100 superficial feet in the Kaira Division, but by calculating the area in the same way as for concrete roofing (outside to outside of walls and no slopes) the rate would be increased to from 40 to 60 Rupees. The cost for covering 100 superficial feet (similarly measured) is therefore for tiled roofing Rs. 40 to Rs. 60 and for concrete arched roofing Rs. 26 to Rs. 35 excluding iron work. The cost of iron work, or of extra masonry in abutments if iron is dispensed with, must be added, and the amount of this additional item depends on the circumstances of each building, but for a series of police quarters or cells or similar structures it is found in practice that the total cost of concrete roofing is generally about the same as for double tiles and teakwood, though in favourable cases it is sometimes less.

Comparison of cost.

The main advantage of this concrete construction is that the roofs require practically no repairs, and experience gained in constructing and maintaining more than 25,000 superficial feet in the Kaira Division during the past 12 years has established its economical character in this respect. Occasion-

Repairs.

ally the plaster requires looking to, and small cracks have to be filled in as in flat roofs, but in many instances, during the 10 to 12 years referred to, nothing whatever has been necessary.

General.

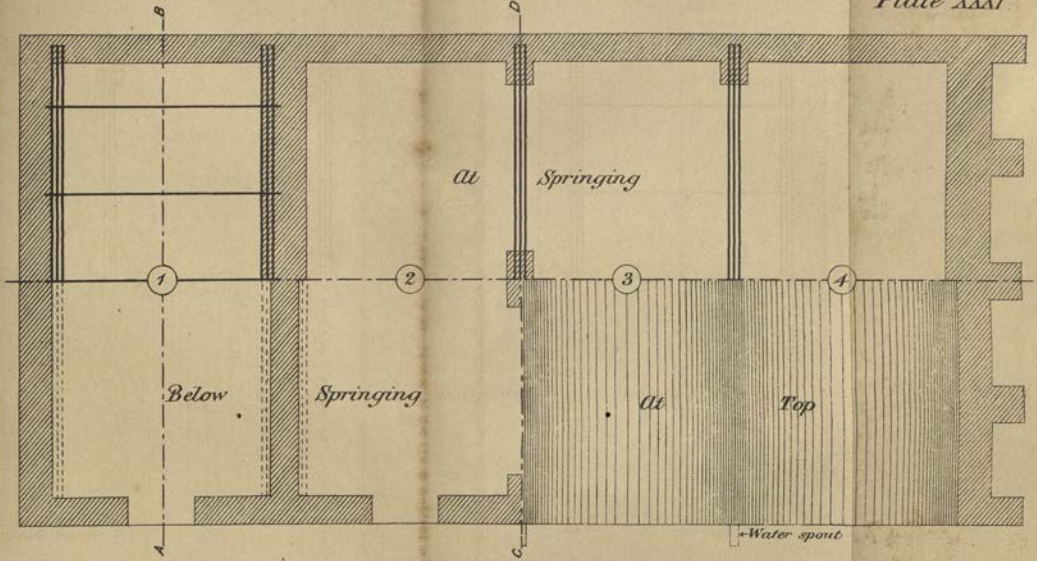
Some experiments have been tried at Kaira with arches of 20 feet span of concrete formed with lime, and also with Portland Cement, and with a mixture of the two. These arches have been made from 4 to 6 inches in thickness, but have been strengthened with iron framing. One of them has been loaded for several years with 150 lbs. to the superficial foot and is quite sound. The cost of these does not exceed that of tiled roofing for similar spans, and may possibly be still further reduced, but more experiments are desireable before practically extending this system of roofing to spans above 10 feet. When cement is used it is necessary to mix the materials dry, and to add the cement and water just before the concrete is required.

Old concrete roofs.

Flat roofing of concrete (without timber) is found in some of the old Mahomedan buildings in Gujarát.

Plan

Plate XXXI



Scale, 5 feet to an inch.

Brick and lime masonry
Concrete in Arches
Other Concrete
Iron Beams and L iron
Iron Bars or rods

This plan shows several arrangements for Concrete Roofing one or more of which may be adopted according to requirements.

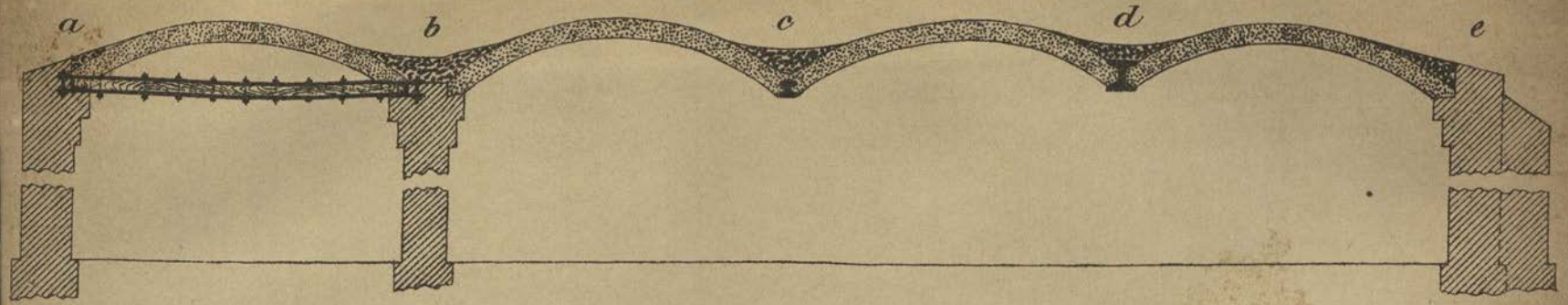
For a row of Police Quarters or Cells, the end spans may be either according to span ① or ④ and intermediate spans require no iron work but would follow the left half of span ②

For a large room in which pillars may be introduced, Railway rails can be used, but where this cannot be done and where the bearing is considerable, Girders must be provided.

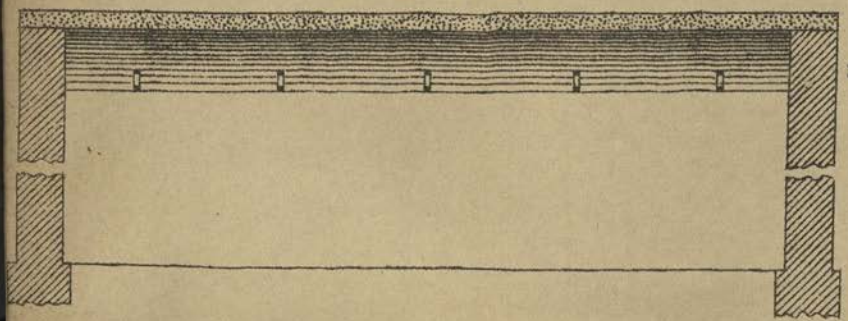
Govt Photozinco-Office, Poona, 1887

For references see Plate 31.

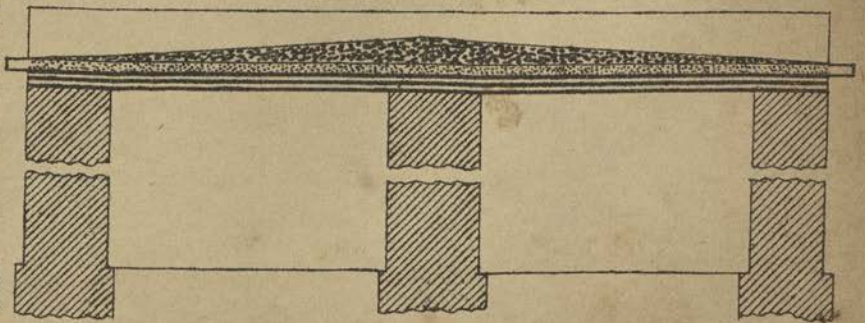
Longitudinal Section.



Section on A.B.

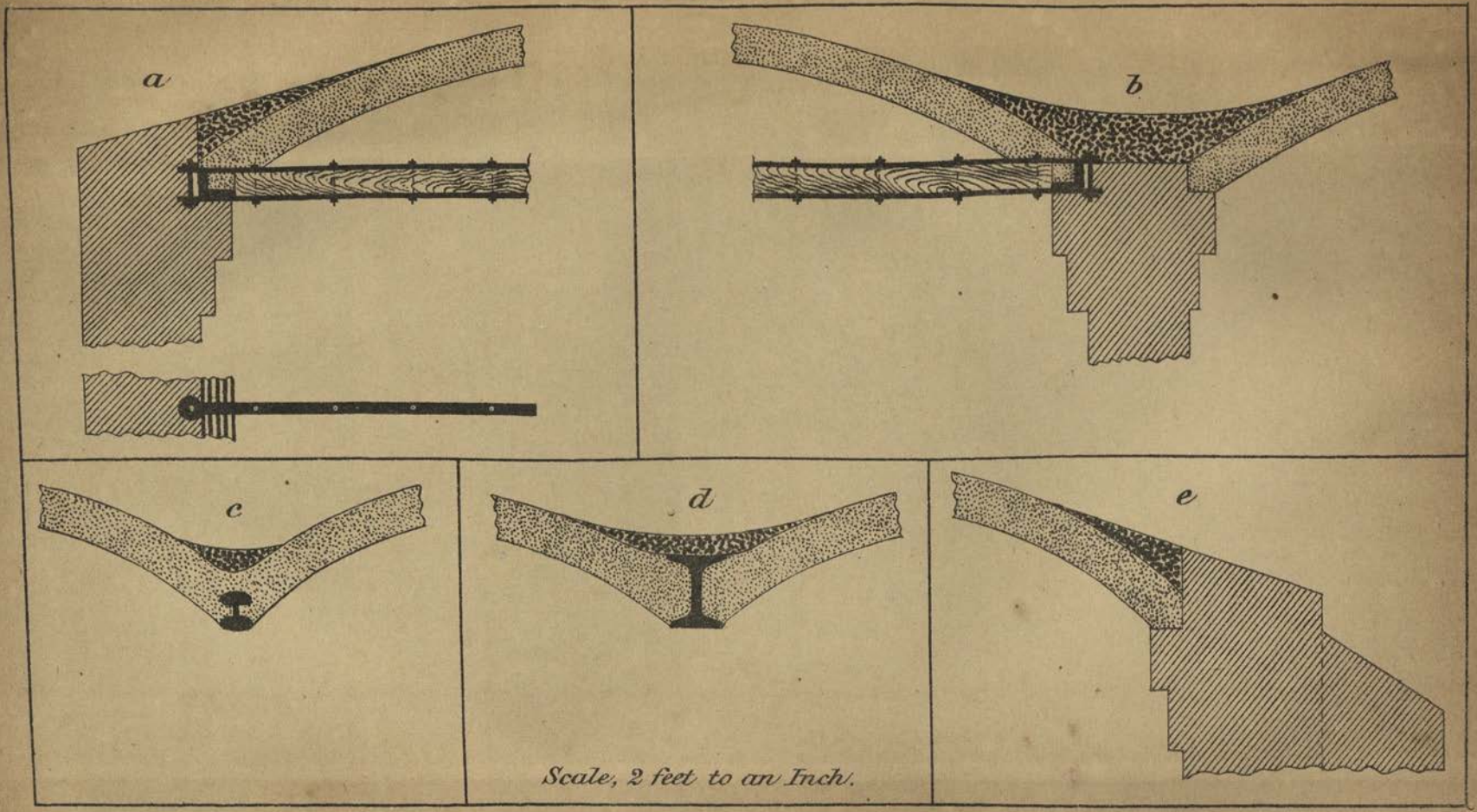


Section on C.D.



Govt Photozincc Office, Poona 1887.

Scale, 5 feet to an Inch.



Govt Photozinco Office, Poona, 1887.

INSTRUCTIONS FOR USING DYNAMITE.

Dynamite can be procured from—

Messrs. MaCaulay and Co., Bombay.
Messrs. Best and Co., Madras.
Messrs. Andrew and Co., Calicut.

Its prices at either of the above seaports are—

	Rs.	a.	p.
Nobel's No. 1 dynamite, per lb.	1	8	0
Treble's detonators, per box of 100	2	2	0
Nippers for fastening detonators	0	6	0
Improved do. do.	2	0	0
Gutta-percha (tape) safety fuze (Bickford's) for blasting in wet places and submarine works, per coil of 24 feet	1	2	0
Red tape safety fuze, per coil of 24 feet	0	7	0
White tape fuze, per coil of 24 feet	0	8	0

The cartridges are of two kinds, one $\frac{7}{8}$ inch diameter, $3\frac{1}{2}$ inches long, and weighing each two ounces; the other 1 inch in diameter, $3\frac{1}{2}$ inches long, and weighing each $2\frac{1}{3}$ ounces. The cartridges are made up in 5 lb. packages and ten of these packages are placed in each wooden case. A ton of dynamite weighs 2,000 lbs.

Dynamite is exploded by means of percussion caps. These are provided in tin boxes and kept laid in saw-dust; before using them the saw-dust must be blown out with a dry blow of the mouth. One end (cut square) of the Bickford's fuze is pushed into the cap until it touches the white fulminate within it. The cap is then compressed with pincers near the open end to connect it with the fuze. Care must be taken that the pressure used is not too great. In damp or wet places the junction is made water-tight with grease, white lead or tar smeared over the outside of the junction. The fuze and cap being ready a primer is opened at one end and the cap gently pushed into the dynamite so that a part of it is still visible, care being taken not to push the cap over head into the primer. The paper of the primer is then closed up and bound very securely with wire or twine to prevent displacement of the cap.

One cartridge is first placed in the bore-hole and *pressed or squeezed, not rammed,* down with a *wooden,* never an iron or metal, rod in such a way that it forms a good contact with the sides of the rock; this process is repeated with a second, third or more cartridges according to the magnitude of the blast. Finally, the primer furnished with the cap and fuze is lowered or pushed gently, but not rammed into the bore-hole until it rests on the charge. The space for about 8 inches above the charge is then gently filled with dry clay pressed home, and the

rest of the tamping for a depth not exceeding 2½ feet is formed of any material conveniently at hand gently packed with the wooden rammer. After this is done the fuze may be lighted.

In blasting rocks with dynamite, the following general principles should be observed.

The mode of proceeding is very much the same as for powder, only the holes should be further apart, of similar depth, but of smaller diameter. The following are the diameters of drills used for different depths of bore hole :—

From	3 to 6 feet	...	...	1 inch in diameter.
„	6 to 11 „	...	...	1½ to 2 inches in diameter.
„	11 to 15½ „	...	...	2 to 2½ „ „

The depth of the bore-hole should be about the same as the L.L.R., and, if possible, the bottom of the hole should never descend below the level of the face of the rock. The bore-holes should not, as a rule, be more than 5 feet deep, and their distances apart from one and a-half to two times their depth. When a large isolated rock has to be blasted with an L.L.R., so great that 5 feet in depth of the bore-hole cannot contain the full charge, two or three holes should be bored close together to about 5 feet in depth and about a foot apart, and each be loaded with rather more than half or one-third of the full charge and exploded simultaneously. A similar method may be adopted in cases when the rock is wedged in a re-entering angle, or is so awkwardly placed as to require a heavy charge. Charges thus distributed and simultaneously exploded in holes close together have a much better effect than a big single hole containing the entire charge.

Cracks and fissures in rock to be blasted should be carefully studied in order to enable the blaster to decide on the best position for the bore-holes. The charge of dynamite should always be laid in a sound piece of rock, not nearer to a crack, if practicable, than one foot.

When rocks have to be shattered by means of dynamite it is absolutely essential to insure between the dynamite and the rocks operated on a close connection, and also to multiply as much as possible the points of contact. These are points of the first importance and should always be borne in mind when using dynamite. For this reason several bore-holes of moderate diameters are preferable to one hole of a larger diameter.

In the case of a gently sloping rock with no face, dynamite should be used very much as powder is, only with shallower and fewer bore-holes. As the line of least resistance is not so important in dynamite as in powder, the necessity for sloping the holes is not so great.

But, if a face be required on an almost level flat rock, sloping holes must be resorted to.

Tamping.—Clay is, on the whole, the best material for tamping. But in using dynamite tamping is not nearly of so great importance as it is when powder is used. It is not worth while to take much trouble in procuring clay. Water tamping should only be used in wet places, or when the charges are fired by electricity; it is a little more expensive than dry tamping and it takes a little longer time.

When a miss fire occurs with water tamping it is only necessary to remove the fuze and primer from the whole and put in a fresh one. But when any stiff tamping is employed in case of a miss fire, the tamping must on no account be removed; it would be dangerous to do so. A fresh hole must be bored not nearer than 6 inches to the old one, be loaded anew and exploded in the ordinary way. The explosion of the charge in the new hole will almost always explode the first charge. But should the first hole be one of considerable depth it will only be necessary to make the new hole 6 inches lower than the top of the charge of dynamite in the old hole. Where the rock is vertically stratified or is likely to crack in one direction more than in another, the new hole should be bored on this weakest line.

Nobel's No. 1 dynamite cartridges are made for 1 inch bore-holes. Where holes of larger bore are drilled the dynamite should be taken out of its parchment wrapper, dropped into the hole and squeezed with the wooden rod so as to completely fill the hole.

In calculating the explosive charges of dynamite to blast rocks, the following formula should be used:

$$W = \text{the explosive charge in ounces avoirdupois} = A.\ L.\ L.\ \sqrt[2]{R}$$

$$L.\ L.\ \sqrt[3]{R}.$$

Where A and B are co-efficients to be determined by direct experiments.

The accompanying table gives charges for gneiss rocks under the conditions assumed.

The following articles are required in using dynamite:—

For every 1,000 lbs. of dynamite—

2 pairs of nippers for fastening detonators to fuze.

6,000 running feet Bickford's fuze of sorts for wet and dry holes.

150 or 200 steel jumpers 1 inch diameter and 8 or 10 feet long.

3,500 detonators.

Data for blasting 100 Cubic Feet of Rock.

Rate.

	Rs.	A.	P.
1 lb. of dynamite, at 1-8-0 per lb.	1	8	0
7 running feet of boring	2	5	4
4½ coolies removing rocks after blasting, at 4 annas each	1	2	0
6 running feet of fuze, at 0-4-6 per yard	0	3	0
3½ detonators, at 2-0-2 per 100	0	1	3
Sundries	0	4	5
Cost per 100 cubic feet ...	5	8	0

TABLE.

EXPLOSIVE Charges of Dynamite in Ounces Avoirdupois to blast Gneiss Rocks under the various conditions shown. Charges calculated from the Formula: W = charge in Ounces = A (L.L.R.)³ + B (L.L.R.)³ for solid rock.—For Boulders by Ounces to Square Foot of least Vertical Section.

ILLUSTRATIONS.

Explosive employed.	Solid attached Rocks.				Loose detached Rocks.	ILLUSTRATIONS.				
	Different conditions of Rock Blasting.	Only one Face and that not clear; footings of Rock requiring bore-holes to be below bottom of Face.	Only one clear Face; bottom of bore-hole being above foot of Face of Rock.	Two clear Faces.	Three clear Faces.	Different conditions of Boulder Blasting.	Bored Hole bored in detached Rock to proper depth, viz. ⅓ Height of Rock.	Vertical Hole bored ⅓ Height of Rock in Depth.	Several vertical Bore-holes ⅓ Height of Rock in Depth and 2 feet apart.	Dynamite laid on Rock with no Bore-hole and covered with Clay, &c.	Dynamite laid on Rock and exploded without being covered.
FORMULÆ WITH VARIOUS CO-EFFICIENTS.		W = A (L.L.R.)³ + B (L.L.R.)³ A = 1 : B = ½ W = Charge in Ounces.	W = A (L.L.R.)³ + B (L.L.R.)³ A = ½ : B = ½ W = Charge in Ounces.	W = A (L.L.R.)³ + B (L.L.R.)³ A = ½ : B = ¼ W = Charge in Ounces.	W = A (L.L.R.)³ + B (L.L.R.)³ A = ¼ : B = ¼ W = Charge in Ounces.	BOULDERS.	EXPLOSIVE CHARGES OF DYNAMITE IN OUNCES AVOIRDUPOIS.				
LINES OF LEAST LEAST RESISTANCE OR L.L.R. IN LINEAL FEET.	Explosive Charges.		Explosive Charges.		Explosive Charges.		Explosive Charges.		AREA OR LEAST VERTICAL SECTION IN SQUARE FEET.	Ounces of Dynamite to 1 Square Foot of Least Vertical Section.	One Ounce of Dynamite to every 2 Square Feet of Least Vertical Section.	One Ounce of Dynamite to every Square Foot of Least Vertical Section.	Two Ounces of Dynamite to every Square Foot of Least Vertical Section.	Four Ounces of Dynamite to every Square Foot of Least Vertical Section.
	Avoirdupois.	Fraction of (L.L.R.)³ in lb.	Avoirdupois.	Fraction of (L.L.R.)³ in lb.	Avoirdupois.	Fraction of (L.L.R.)³ in lb.	Avoirdupois.	Fraction of (L.L.R.)³ in lb.						
	ozs. lb.		ozs. lb.		ozs. lb.		ozs. lb.		sq. ft.	ozs.	ozs.	ozs.	ozs.	ozs.
1	11 = 0	⅓	1 = 0	⅓	1 = 0	⅓	1 = 0	⅓	—	—	—	—	—	—
½	5 = 0	⅓	½ = 0	⅓	½ = 0	⅓	½ = 0	⅓	¼	4	2	4	8	16
¼	2 = 0	⅓	¼ = 0	⅓	¼ = 0	⅓	¼ = 0	⅓	1	16	8	16	32	64
⅛	1 = 0	⅓	⅛ = 0	⅓	⅛ = 0	⅓	⅛ = 0	⅓	4	64	32	64	128	256
1	11 = 0	⅓	1 = 0	⅓	1 = 0	⅓	1 = 0	⅓	—	—	—	—	—	—
2	5 = 0	⅓	2 = 0	⅓	2 = 0	⅓	2 = 0	⅓	4	16	8	16	32	64
3	2 = 0	⅓	3 = 0	⅓	3 = 0	⅓	3 = 0	⅓	9	36	18	36	72	144
4	1 = 0	⅓	4 = 0	⅓	4 = 0	⅓	4 = 0	⅓	16	64	32	64	128	256
5	0 = 0	⅓	5 = 0	⅓	5 = 0	⅓	5 = 0	⅓	25	100	50	100	200	400
6	0 = 0	⅓	6 = 0	⅓	6 = 0	⅓	6 = 0	⅓	36	144	72	144	288	576
7	0 = 0	⅓	7 = 0	⅓	7 = 0	⅓	7 = 0	⅓	49	196	98	196	392	784
8	0 = 0	⅓	8 = 0	⅓	8 = 0	⅓	8 = 0	⅓	64	256	128	256	512	1024
9	0 = 0	⅓	9 = 0	⅓	9 = 0	⅓	9 = 0	⅓	81	324	162	324	648	1296
10	0 = 0	⅓	10 = 0	⅓	10 = 0	⅓	10 = 0	⅓	100	400	200	400	800	1600

Nobel's Dynamite No. 1.

SANITATION OF WORKING PARTIES.

When large gangs of work-people are engaged on works, particular attention must be given by the officer in charge to sanitary requirements, especially in malarious districts or where epidemics prevail. The great requisites for preserving the health of the work-people are (1) proper accommodation, (2) food, (3) water, (4) conservancy. These will necessarily vary according to locality and circumstances, and the following remarks are offered merely to illustrate the general nature of the precautions necessary.

2. *Accommodation.*—Huts of bamboos and grass can be constructed at little expense in most parts of the country, and they will be amply sufficient for the accommodation of the work-people.

3. In erecting them, it is of great importance to select a good site. High ground removed from jungle, but well provided with trees, ought to be chosen wherever it is available. The neighbourhood of rank jungle, grass, or weeds, is particularly to be avoided; newly turned soil is also deleterious, so that camps should not be established close to large cuttings or earthworks.

4. The houses themselves should be raised on an earthen plinth, and with open spaces of at least 10 yards between the different rows. When a good natural site cannot be procured, the drainage should be particularly attended to. Whenever, owing to unavoidable circumstances, the huts occupy a situation in a low, swampy, or otherwise unhealthy situation, the sides should be carefully *leeped* or thinly plastered with mud so as to exclude the night air, and in such circumstances it will also be advisable that the people should sleep on raised cots or *charpoys*.

5. It is very important that there should be no overcrowding; each person should be allowed at least 50 superficial feet, and care should be taken to see that the houses are kept clean and in good order.

6. *Food.*—As regards food, in most parts of India no difficulty will be experienced in providing a good and sufficient supply. In many cases no special arrangements will be necessary, as the coolies will be able to draw their supplies from a neighbouring market without difficulty. Where no such facilities exist, it will be advisable to organise a bazaar, and to see that the food provided is proper, both as regards quantity and quality. In this respect, it is of importance also to secure a sufficient variety, and, in addition to the ordinary staple articles of rice, dhall, ghee, and condiments, such valuable additions to diet as goats, fowls, and vegetables, should not be omitted.

7. *Water.*—Good and pure drinking water is of hardly less consequence than good food. Well water is generally to be preferred, as being more free from impurities. The wells should be sunk in such a situation as will prevent their being contaminated by sewage. They should be reserved for supplying drinking water, and no person should be allowed to bathe over, or even near them. Where the water is drawn from tanks, similar precautions should be adopted. The tank should be kept for supplying drinking water, and no persons should be allowed to wash either their bodies or their clothes in it.

8. *Conservancy.*—General cleanliness of the lines and their vicinity should be enforced. As the encampment will probably be constantly moving with the progress of the works, it is not advisable to establish regular latrines. Under the circumstances, the trench system is most suitable. Every morning one or more fresh trenches should be dug, according to the number of people to be provided for. They should not be deeper than 1 foot, and should be covered in daily. In selecting a site for these trenches, it is indispensable that they should be removed as far as possible, consistent with convenience, from the water-supply. The system has no other danger than contamination of the water, and it can be effectively carried out at very little expense.

9. The precautions noted under these different headings, if carefully attended to, are calculated to secure the health of the people employed. It is now necessary to consider what measures should be adopted in the event of sickness appearing among them.

10. Wherever any large body of coolies is collected together, it will be advisable to appoint a native doctor, and provide a small hospital. In most cases, a central establishment will be sufficient for several miles of works. The hospital should be reserved for treating accidents and cases of a trifling nature, in which complete recovery may be soon expected. As a rule, it will be better to transfer the sick suffering from more severe illness to the neighbouring station, where they can be looked after in the dispensary.

11. These remarks apply more particularly to ordinary cases of sickness. Those diseases which are liable to become epidemic require separate attention. Under this head there are only three which need be considered. They are small-pox, cholera, and contagious fever.

12. Small-pox is rarely epidemic among adult natives. On the appearance of any case, no matter how slight, the patient should at once be removed to a small-pox hospital, if one exists in the neighbouring station. If there is no special hospital for the reception of such cases, the sick man must be isolated in a separate hut, well removed from the rest of the people, and all communication between it and the camp must, as far as possible, be cut off. On his becoming convalescent he should be provided with new clothes, and sent to his home; on convalescence or death, his clothing and all other infected articles ought to be destroyed.

13. The occurrence of a case of cholera has a different significance according to the part of the country and the particular time of year at which it occurs. Under any circumstances, however, the appearance of

even one case of the disease should not be lightly thought of. The care taken in the conservancy arrangements should be redoubled; the patient should be isolated, and his discharges disinfected. Cholera pills should be freely distributed, so that cases of diarrhœa may be treated without delay. If the disease becomes epidemic, that portion of the encampment which has been attacked should be vacated without delay, and if the attack has not been limited to any particular locality, it will be advisable to remove the whole of the people elsewhere. A move of even one or two miles often suffices.

14. In highly malarious localities where fever of a dangerous type prevails, care should be taken that all the party are within doors immediately after sundown. The huts ought to be shut up at once for the night, no communication with the external atmosphere allowed, and no one permitted to leave for work until the sun has risen. Each member of the gang ought to be given daily, at morning parade, one or two fever pills or such febrifuge as the native doctor may prescribe. Particular care must be taken to prevent the work people remaining in wet clothes or sleeping on the ground.

15. The question of medical supervision has already been incidentally alluded to. It will be advisable, as has been already stated, that a native doctor, with a small hospital, should be attached to each large gang, or set of gangs, of work-people. It is also necessary that he should be under supervision. Whenever circumstances admit of it, the camp should be frequently visited by the Civil Surgeon of the district. Even when distant from his head-quarters, it is very desirable that he should pay at least one visit in the month to ascertain that the native doctor is carrying on his duties properly, and also to satisfy himself that the sanitary arrangements are good. A weekly report should be submitted by the native doctor to the Civil Surgeon. He would thus be informed of what was going on, and on the occurrence of any emergency, his services would always be available when called for by the Engineer in charge.

16. It is the duty of Superintending Engineers to see that the general orders on the subject of health are duly carried out.

17. Any reasonable outlay for such temporary cover as may be needed for bodies of work-people of considerable magnitude, and for the marking out, clearing, and draining of their temporary stations, also for entertaining one or two policemen, hospital establishments, and some small temporary establishment to look after the latrines, may be authorised as forming part of the contingent outlay on the work under execution.

Miscellaneous Notes.

Average price per cubic foot of the different descriptions of buildings erected by the War Department.—Amount arrived at by taking the outside dimensions above foundations for length and breadth. Height ½ way up roof and ½ depth of foundations including footings and concrete.

	d.
Officers' Quarters	8½
Soldiers' Barracks	6
Married Soldiers' Quarters	6½
Stables with Quarters over	5
Stables	9
Chapel School	4½
Recreation Rooms	4¼
Gun Sheds	3½
Gymnasia	2½

The cost per cubic foot of the principal Government buildings erected by the Public Works Department in Bombay has been as below. The measurements being taken as follows :—Height—from the ground line to half way up the length and breadth—the exterior dimensions of superstructure; Verandahs taken as solid.

	Rate per cubic foot. Annas.
Elphinstone College	10·
Mechanics' Institute	11·
Eye Hospital	5·66
Incurable Hospital	6·83
New Secretariat	7·33
Public Works Offices	7·25
University Hall	9·50
„ Library	9·83
Clock Tower	15·66
Native General Hospital	5·83
New Post Office	5·92
New High Court	5·00
Telegraph Office	4·92
Sailors' Home	4·58
New High School	4·66
School of Art	4·25

Size of Racquet Courts.—The small court at Prince's, 60′ × 30′ × 30′ high; R. M. Academy, Woolwich, 64′ × 32′; Byculla Club, 75′ × 36′; Kirkee, 73′ × 34½′; Poona, 72′ × 34′.

Temporarily Restoring Drawing Paper.—From *Bombay Builder*, 1865. The quantity given is sufficient for a sheet of Antiquarian.

Isinglass 6 grains, alum 2 grains, water 3 fluid ozs. Soak the isinglass for an hour or two to soften the threads in 2 ozs. of water; add the 3rd oz. and simmer gently till the isinglass is dissolved. Then add the 2 grs. of alum in powder or dissolved in a small quantity of water; stir thoroughly and strain through fine muslin. The paper

should be mounted and brushed over while damp with the solution applied by a broad flat brush. When quite dry it should be sponged with a liberal supply of water to float off loose patches of size. If the paper shows spots on being wetted, the operation should be repeated; twice is sufficient generally even in a bad case.

Size of Drawing Paper.

Demy	20″ × 15″
Medium	22″ × 17″
Royal	24″ × 19″
Super Royal	27″ × 19″
Imperial	30″ × 22″
Columbier	34″ × 23″
Double Elephant	40″ × 27″
Antiquarian	52″ × 31″
Extra „	56″ × 38″
Atlas	34″ × 26″

China and Glass Cement.—Equal parts, by weight, of beeswax, sulphur and rosin; melt wax on sand bath, and rosin powdered, and then sulphur till sublimed; then apply to broken pieces also heated on sand bath.

To purify Water for drinking.—Add to the water to be purified a few drops of permanganate of potash (costs about Rs. 1 per ½ oz.). If the pink colour disappears, there is organic matter present, and the permanganate should be added until the pink colour is permanent. It is best to test a small quantity of water first, and then to add as much as necessary to the day's supply.

The water can afterwards be filtered through clean sand and charcoal with advantage. Permanganate of potash destroys organic matter already in a state of putrefaction instantaneously; but it takes half an hour or more to destroy matter about to putrefy.

Alum, *i.e.* sulphate of alumina, is highly valuable as a purifying agent. It attaches itself to organic animal matter, living germs, &c., and converts them into an insoluble substance like leather. It may be used independently or in combination with permanganate of potash.

Cleaning Saddlery or Leather Work.—Beeswax 6 ozs., resin 3 ozs., linseed oil ¼ pint, mix and stir together in saucepan; take off fire, add 1 pint neat's foot oil, ½ pint turpentine, and 1 oz. camphor, and pot for use.

Leather Preservative or Emollient.—Castor oil is the best known. It does not prevent polish from blacking, and it is said that leather so treated will not be attacked by rats or mice.

Metal Screws or Bottle Stoppers.—To remove apply plentifully spirits of turpentine; this will loosen screws or stoppers almost immediately.

To harden Steel.—The article to be made white hot and then thrust into sealing-wax (common lac), withdrawn, and then insert again in another part, and so on till cold.

Alloy that expands in cooling:—

9 parts lead.
2 antimony.
1 bismuth.

Wooden Labels, to preserve.—Soak in a strong solution of sulphate of iron; when dry place them in lime water. This causes formation of sulphate of lime and will last for years.

Zinc, to write on.—Use solution of sulphate of copper (blue vitriol) with a quill pen.

Waterproof Mixture.—For under water blasting—

Tallow	... 5 per cent.
Rosin	... 15 „
Gutta percha	... 20 „
Pitch	... 60 „

Fumigation.—Adopt one of the following processes:—

With chlorine gas:

(*a*).	Take common salt	... 4 ozs.
	„ oxide of manganese (in powder)	... 1 „
	„ sulphuric acid	... 1 „
	„ water	... 2 „

The water and acid to be mixed together and then poured over the ingredients in a delf basin, which should be placed in a pipkin of hot sand.

With nitric oxide gas:

(*b*).	Take copper shavings	... ½ oz.
	„ nitric acid	... 1½ „
	„ water	... 1½ „

Pour the acid and water upon the copper in a small jar.

(*c*). With sulphurous acid gas:

Burn 2 ozs. of sulphur in a pipkin.

All doors and windows to be closed before commencing fumigation.

The operator will leave the room immediately the process is commenced.

At the expiration of from 2 to 3 hours all doors and windows will be thrown open to free ventilation.

Rooms to be completely emptied before fumigation is commenced.

To render Glass opaque or Frosted.—Clean the sheet of glass; and if only portions of it are to be frosted, protect the portions not to be frosted by mechanical means in any simple manner.

Some fluor spar is ground to a fine powder and mixed with concentrated sulphuric acid so as to form a thin paste, and this is rubbed by means of a piece of lead upon the parts to be rendered opaque. This process is known as "Etching on glass" by "hydrofluoric acid."

Gently heat the glass, when noxious fumes will be given off. On cooling, the plate is washed with dilute solution of soda and potash to remove any acid yet remaining, and is then rinsed in water.

Care should be taken that the fluoric acid does not get on the skin.

White Ant Lotions:—

		Lbs.	ozs.
1 *Arsenical.*—Arsenic	...	2	4
Dhobi's mud khar	...	2	8
Soap, country ...	...	2	13
Aloes (Ærea) ...	...	2	4
Water	...	4 gallons.	

Pound ingredients fine, mix, boil in half the water in earthen or iron vessel. Let it cool, then add the rest of the water and boil again. Cost about Rs. 1-5-3 per gallon. Does not stand exposure to rain, being more for inside work. Wood, if possible, to be steeped; but if applied, a solution will answer.

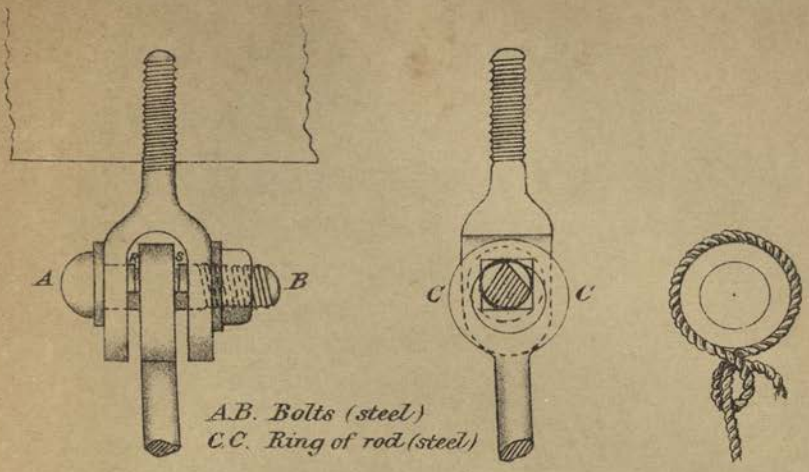
2. *Copper Sulphate*—(blue stones or moorchood) 1 lb. dissolved in 4 gallons of water (costs 4 annas per gallon), takes two days steeping per inch of wood.

3. McDougal's sheep dipping composition 1 lb. to 5 gallons; costs about 2 annas per gallon.

Varnish for Name-Boards, Labels, &c.—Sandrac 53 parts, mastic 20 parts, camphor 1 part, oil of lavender 8 parts, Venice turpentine 4 parts, ether 6 parts, alcohol 40 parts. Macerate for a week or two until the whole is dissolved. This makes a good varnish, with colourless smooth and shining coat, and dries in a few minutes.

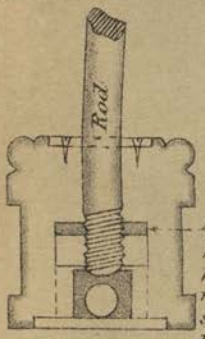
Method of hanging Pankhas

Plate XXXIV.



A.B. Bolts (steel)
C.C. Ring of rod (steel)

Cross Section of Pankha Bar shewing method of connecting Rods or hooks to receive ropes



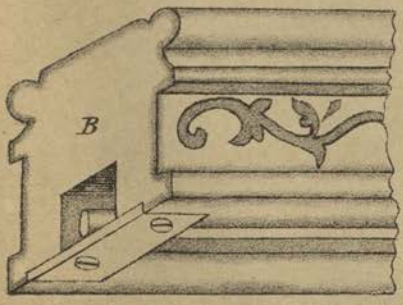
Nut to be placed in position & rod or hook screwed thereto.

A B C D. Square in Section

O.P. Purposely sunk to keep ring of rod or ring from contact of edges R.S.

Section

Ring for Rope Suspender



The brass rod may be in one or several lengths arranged to coincide with brass plates. Carved or turned bosses. plugged, screwed at end of bar, to keep rod or rods in position. Blackwood inland or not according to requirement.

Carved boss, plugged, screwed to cover the end B.

Govt Photozinco Office, Poona, 1867

XI.—DRAINS, CULVERTS, AND BRIDGES.

PART I:—DRAINS AND CULVERTS.

II:—BRIDGES.

III:—MEMORANDUM ON THE PREPARATION OF ROAD PROJECTS.

		Page.
PREFACE	... ...	347
PART I:—DRAINS AND CULVERTS	... ...	349
Do.	Table I	363
Do.	Do. II	371
Do.	Appendix	378
Do.	Table A	380
Do.	Do. B	381
Do.	Do. C	382
Do.	Do. D	382
Do.	Do. E	382
Do.	Do. F	383
	Plates XXXVI. to XLVII.	
PART II:—BRIDGES	... ...	384
Do.	Table I	391
Do.	Do. II	401
Do.	Appendix	406
Do.	Table G	407
Do.	Do. H	409
Do.	Do. I	410
Do.	Do. J	411
Do.	Do. K	412
Do.	Do. L	413
	Plates XLVIII to LII.	
PART. III:—MEMORANDUM ON THE PREPARATION OF ROAD PROJECTS...		413

PREFACE.

THE primary object of the following pages is to supply Executive Engineers with Tables of the quantities of masonry in small Drains, Culverts, and Bridges of the class usually built on public roads; and thus to facilitate the preparation of Road Projects in their offices. By the use of the Tables, accurate estimates may be framed of the cost at which a road can be provided with drains, culverts, and bridges, while the labour of "getting up" a set of plans and estimates may be saved. In Superintending Engineers' Offices also, there will be a considerable saving to the Office Establishments. This is evident; for, under the existing system, each Executive Officer prepares for every road project he may be required to submit, a set of average plans of his own; from these, detailed estimates must be prepared, checked, and fair copied, before submission to the Superintending Engineer, in whose office they are again checked in every detail. But with these Tables, abstracts merely need be prepared in Executive Offices, and the tabular quantities only checked by the Superintending Engineer's establishment. Thus labor is saved, and the chances of error, both arithmetical and clerical, are considerably reduced. Further, since the Tables give quantities for every height of formation, estimates may without trouble be framed with far greater accuracy than is now ever done, when only a few plans of average heights are prepared, and the quantities in these are assumed on the whole to give a fair average of the cost of each description of masonry structure on the road.

A secondary object aimed at is that, by using the plans in any district, a certain uniformity of construction may be obtained throughout the works, and thus officers will be saved the necessity of furnishing working drawings to their subordinates for the small road-masonry constructions. Officers thus relieved of the details of the smaller works will have greater leisure to devote to the designs of the more important structures.

At the same time it is to be recollected that it is not intended that the plans should be considered to be STANDARD; they should be looked upon more as *Specimen* plans which may be used or not, and for which others may be substituted in practice; but since they will be found to meet fairly all cases of ordinary road masonry structures, it will evidently be a waste of money if the designs substituted for them contain more masonry than they do. It is, however, thought that the designs will to a great extent accord with the practice of most engineers, and may be found useful on works; while, whether or not, the value of the Tables in estimating the outside cost of the cross drainage of roads will not be lessened.

The plans given represent average sized structures, and are hence called "*Average plans.*" In building, therefore, when a drain culvert or bridge is to be of other height or length than that in the average plan, it is only necessary to maintain the same system of design, and in the Tables will be found the exact quantities in the structure.

PART I.—DRAINS AND CULVERTS.

THE plans represent average sized structures. From these plans, estimates have been made; and, from the quantities thus obtained, tables have been framed giving the quantity in each drain, &c., for every formation height.

2. This has been done, by supposing a horizontal slice of one foot in height added to, or deducted from, the piers and abutments, under the line of springing, and assuming a wing of the proper height, for which purpose a general drawing of wings with a table of their contents is prepared [see *Plate* XXXVII. and Appendix].

3. In the tabular calculations all quantities are made to depend on the "formation height." This, in drains, is the height of the top of the extrados of the arching over the level of the bed of the nullah.

4. The length of the drains, &c., has been taken as 22 feet, which is suitable to roads of a width of 20 feet; but a table of the contents of ONE FOOT IN LENGTH of a vertical slice through the crown at right angles to the axis of the bridge, given at the end, enables the contents of longer, or shorter, structures to be calculated with ease, as shown further on [page 359, Art. 49].

5. FOUNDATIONS are supposed to have an average depth of 2 feet; this will cover all ordinary cases, and in special ones extra foundations, such as "concrete blocks," "wells," &c., can be provided. On a road of any length, in most cases, some drains will be found to be on rock and in such, so to speak, no foundations will be required, while it is seldom necessary to go deeper than 4 feet without special provision.

6. Where, however, it is known that a drain will require a greater or less depth of foundation, it will be sufficient to increase, or diminish, the tabular quantities in the foundations in the ratio of the increase, or decrease, of the depths in order to obtain the true contents of same.

7. The EXCAVATION OF FOUNDATIONS is taken as exactly of the size of the masonry of the filling in; but in practice the excavation is always somewhat, and often considerably, greater; this contingency must be covered by a rate which should vary with the conditions of the bed of the nullah.

8. The material excavated is to be thrown into the embankments of the approaches [*see* page 353, Art. 31].

9. The excavation is taken also as only commencing at the level of the bed of the nullah; the excavation above this level, being thrown into the approaches, will be chargeable to "embankment" not to "foundations."

10. FILLING IN FOUNDATIONS is disposed in a single block with a single 6-inch footing, or off-sets in front; but in building it may

be arranged otherwise [as shown in *Figs.* 2, 3, *Plate* XXXVI.] without extra expense. When foundations of greater width than shown are necessary, their area can be obtained by adding a strip [the calculations of the quantities in which, for wings, *see* Appendix, note to Table A.], of the increase in breadth measured along the face of the footing courses; but this is seldom necessary. No off-set is shown at back as excavation for it; it tends to disturb the solid earth there.

11. INVERTS and APRONS, may be considered as "paving," and can be introduced, as shown in the plans by dotted lines. The quantities in the inverts and aprons are given separately, as it is not always necessary to use an apron, although an invert may be required. Square measure has been adopted, but it is easy to convert it into solid measure if required, or if that will suit the rates of a district better; and the rates should be made to include any excavation necessary in laying the masonry.

12. The versed sine of the inverts are taken as one-fifth the chord, and therefore the radii of their curves correspond to those of the segmental arches.

13. The areas of the aprons are calculated a *little* in excess of what they measure on the horizontal projection to allow for a slight dip towards the middle. Of course neither inverts nor aprons, will be necessary when foundations are on rock or hard moorum.

14. ABUTMENTS are without batter on face, or back; and are of an average thickness (except in the smaller structures) of one-fourth the span.

15. COUNTERFORTS, although they save a little masonry, and might be introduced in practice, are not in these Tables calculated for, except in the higher structures; that is to say, those in which the height of formation exceeds six times the thickness of abutment shown in plan. In this case, counterforts 3×5 feet, reaching to springing level of semi-circular arches, are added at the centre of the back of the walls. [For their quantities, *see* Table D., Appendix.]

16. ARCHES are either semi-circular, or segmental with a rise of one-fifth the span. The depth of ring is a little greater than what is sometimes given to road drains in India; but it is considerably less than English practice, and as light railways are sometimes laid on our roads, it is well to have substantial arches.

17. The Tables are calculated for semi-circular arching; but the difference between the quantities in segmental and semi-circular arched culverts is given at the foot of the tables in each case, and an elevation of both descriptions of culvert is given in each plan.

The water-way gained by segmental arches is inconsiderable in small bridges, but the cost is somewhat less.

SLABS are 6 inches thick, because of their liability to fracture. The area given in the tables is *the area over the opening only.* If necessary, rates must be struck for this area, for the local custom of a district

may have fixed the price of slabs by the length of slabstone, or by the length per foot of drain, or by the cubic foot. Slabs rest 3 to 6 inches on the walls.

18. Haunching or Backing to Arches.—The following rule for its form, taken from an average of a number of practical examples, has been adopted:—Draw a line tangent to the extrados, making an angle of 20 degrees with the horizontal, and carry up the line of the back of the abutment till it cuts this. The slope is therefore $2\frac{3}{4}$ horizontal to 1 vertical [see *Fig.* 4, *Plate* XXXVI.]

The result of this rule differs little from one given in Rankine's "Civil Engineering," and depends on the form of the arch, not on the thickness of the abutment, which some other rules do.

19. Centering is of mud and stone, filling up the opening of the arch [as in *Fig.* 5]. In the longer culverts, when the rise is great, it will probably be more economical to use rough trusses to support, and, at the same time, decrease the quantity of the mud and stone packing.

In any case the rate for the mud and stone should include the cost of its support by cross pieces, or trusses, as may be [*Figs.* 5, 6, and 7, *Plate* XXXVI. show the modes of support].

20. When a large number of culverts have to be built, a framed centre might with economy be used for the larger culverts; and a crib, or frame, in 5 feet lengths for the smaller.

The use of a crib, in building drains in short lengths, is not much known among the masons of India, and they would at first probably require to be taught how to work with it. For the 10 feet culvert a framed centre is used. The ribs may be lowered, by sand boxes, as shown in the drawings.

21. Wingwalls.—A general design [see *Plate* XXXVII.] has been adopted for all culverts and drains. The walls are plumb faced, and batter at the back 1 in 4; and are designed with an average splay of 1 to 1. The slope of their upper surface is that required to coincide with a bank sloping at $1\frac{1}{2}$ to 1; and in building them care must be taken that a level line stretched over them at any point and parallel to the face of the bridge, shall touch both the front and back edges.

The breadths of the walls at top, on the square, is 1 foot 3 inches, and the walls have a stability about equal to that of vertical rectangular walls with bases equal to one-fifth their height

22. The wing walls are invariably drawn, and their contents calculated, as if to be built of the full length. In practice, however, much masonry may be saved by taking skilful advantage of the conformation of the banks of the nulla, so as to reduce the splay when the banks are abrupt, and to step the walls up the bank when the hardness of its material will admit of it: this is shown in [*Fig.* 8] by dotted lines. In every case the wings should be cut off short where their upper slope meets the ground, as shown by heavy lines in the same figure.

23. Particular attention should be paid to the introduction of "weep holes," a, a, through the bases of all high walls [*Fig.* 8, *Plate* XXXVI.]; and such walls should be drained at the back by a packing, or filling of waste stone, chips and shivers, laid behind them as the work proceeds.

24. The height of wing at shoulder is equal to the height of formation, or line of top of embankment under the mooruming. Hence the top plane of the wall will exactly coincide with that of the slope of the bank. If a wing rising slightly over the plane of the side slope be required, it is easily managed by adding a paving, or coping, to the top of the wall; this, if 4 inches thick, will add about 6 inches to the height of the wing, but although the coping looks well, the junction of the wing and the slope, unless carefully sodded, will look badly. The length of this coping or paving is calculated in Table C.; and an item for it can be entered in estimates if required. COPING TO WINGS, appears unnecessary in *Drains*, as it is generally sufficient to finish off the top of the wall with a species of flat quoin stone.

25. The contents of wings are obtained by the "prismoidal formula" (*see* note to Tables A. and B.) *Areas* are taken parallel to the axis, or longitudinal direction of road; *i. e.* parallel to the face of bridge; and *lengths*, perpendicular to same, or parallel to axis of bridge, *i. e.* parallel to line of abutments and direction of course of nulla.

Tables A. and B. give the quantities of wings for each foot in height.

26. When a wing is cut off short [as shown by heavy lines in *Fig.* 8], its content is arrived at by subtracting the tabular content of a wing of the height of the point at which it is cut off, from the tabular content of the wing of the formation height, of the drain [*see* example to Tables A. and B. in Appendix.]

27. When a wing is "stepped" up the bank; assume a "give and take" plane p, p [see *Fig.* 8, *Plate* XXXVI.], along the line of steps, as a practical approximation, and if x be the height of base at end of wall over the level of base at shoulder, then the content of this wall is approximately found by multiplying its length (which is the tabular length due to the given formation height $- x$) by the mean area due to the formation height of the drain [*see* examples to Tables A. and B. in Appendix].

28. When a wing has other splay than 1 to 1 ($\phi = 45°$) its content is obtained by multiplying the tabular content by the secant of the new angle of splay,* and dividing by 1·4 (the sec. of 45°), and this will include with sufficient accuracy the triangles and pyramids at back, if the angles ($\phi° + \beta°$) are kept constant.

---

* Sec. ϕ = sec. of the angle of splay $= \sqrt{1 + (\text{ratio of splay})^2}$. The *angle of the splay* is the angular deviation of the axis of the wing from the direction of the axis of the bridge, or nullah. The ratio of splay is the length the axis of wing deviates in 1 foot measured in direction of axis of bridge. The ratio of splay in these plans = 1.

29. When the side slopes of the "approach" banks have other inclination than $1\frac{1}{2}$ to 1 (angle $\theta' = 33° 42'$), multiply by the horizontal element of the new ratio, and divide by 1·5 (the ratio in these plans); or, tabular number $\times \frac{\text{cot. } \theta°}{\text{cot. } 33° 42'} = \text{content.}$

30. The designs of the wings may be somewhat changed without any increase in the quantities. For example—the face may be made to batter, say up to 1 in 12, provided the breadth of *base* in the tables be adhered to; also, newals may be introduced by cutting off the wall at 3 feet from the small end, and substituting a newal for the triangular piece cut off. The quantities in a newal—as in Part II.—will be compared with those in the end cut off.

	newal.		end
Foundations,	14	against	27
Superstructure,	13·5	,,	14, all cubic feet.

31. No provision is made for FILLING IN OVER THE ARCH and spandrils; because the excavation from the foundations, which is thrown into the banks, will more than cover the item.

32. EMBANKMENTS are usually estimated in the earthwork of the road, if the drain is on a road under construction; otherwise the banks form separate items of calculation from sections taken specially.

33. In all banks a certain space is taken up by the masonry of the drain. In small works a deduction for this is seldom made, the banks being calculated up to a central line, *a*, *b* [*Fig.* 9, *Plate* XXXVI].

In the case, however, of a drain of many openings, the space *d*, *e*, *f*, *g*, occupied by the drain is a considerable item, and should be deducted from the lengths of the banks. This is done by ruling lines on the section, from which the earthwork is to be calculated, corresponding to the lines of the backs of the abutments, and taking out the earthwork on either side only as far as these lines; *i. e.* in figure, the quantities in *h*, *e*, *d*, and *i*, *f*, *g*.

The space *df*, for each drain is given in the tables, where —

S = the space for a single drain.

S′ = the space for each additional span.

Consequently the space, *df*, for drain of *n* spans, will be $S + (n - 1) S'$.

In lengthened drains there should be added to the earthwork of the banks (if high) $\{ S + (n - 1) S' \} \times$ difference of heights of extrados and formation $\times$ length of drain (nearly).*

34. CUTWATERS are provided *only* at the *up-stream* ends of the piers, as they are of little practical value on the down-stream sides. A Table, F., of their dimensions and areas, is given for both triangular and curved cutwaters.

---

* More accurately—

$(H - e) \times \left\{ b + m (H - e) \right\} \times \left\{ S + (n - 1) S' \right\}$ where H = formation height; e = height of extrados; b = breadth of bank at formation level; m = ratio of slopes.

35. PARAPETS are shown in the drawing [*Fig.* 18, *Plate* XXXVIII.], and are supposed to be used for all drains of over 6 feet in height of formation. They are set out 3 inches, to avoid lengthening the drains, and should have *guard stones* placed to protect them; one at each end, and one over each pier. CORNICES, of equal length to the tabular item for copings, should be provided for in the estimates.

36. The *rates* for CORNICES AND IMPOSTS, should only include the extra cost of suitable stones and their dressing; as all the material within the line of the face of the walls is *included* in superstructure.

37. Drains are sometimes designed with the face or head walls, of the structure returned back into the banks instead of with splayed wings.

These are called "returned walls," to distinguish them from "wing walls."

This method of design may be carried out at about the same cost as that of wings in the plans, provided that the conformation of the banks of the nullah does not necessitate returned walls *longer* (measured from the back of abutments) than the height of the formation. The same section of wall may be adopted as that given for wings; but such method of connecting a drain with its approaches is only applicable, with economy, to nullahs with *steep* and *hard* banks.

38. DRAINS are divided into SLAB DRAINS and CULVERTS.

Slab drains are useful when good slates, or easily divided trap or granite rocks, are available for slabs. They have the advantage of requiring no centering, and are quickly built; but are defective, inasmuch as, if the covering slabs are not of good tough stone of sufficient thickness, they are very liable to break under the impact of the wheels of carts, and this the more or less readily as the road material over them is less or more thick. On account of the possibility of their slabs breaking under pressure, it is not safe to use this description of drain under high banks.

Culverts are better adopted for use in cases in which the formation height and water-way are larger than can be economically provided by the use of slab drains.

Where foundations are bad, by the use of inverts, they can be employed with advantage; and under heavy banks they are superior to slab drains.

They also allow of the water-way being readily adapted to the volume of the nullah, as will be explained further on.

39. Direct tables for *lengthening* culverts to suit them for use under high banks, are omitted in this edition, as it is considered better to allow each case to be treated on its own merits [*see* example, page 360, Art. 50] so as to vary the size of the drain with the water-way required.

40. Any drain of a given span may be made suitable to carry a road of any required formation height by either "heightening" it, so that the parapets shall fence the road, as shown in the plans; or by "lengthening" it, so that the top of the drain may catch the toe of the slope.

Heightening a drain may be done in two ways, either by supposing a horizontal slice of the walls let in under the springing line; or (within small limits only) by adding on to the spandril, or head walls over the extrados; and, in either case, using a wing of the height of formation.

The former of these two methods, is that adopted in the tables in which drains are termed "*heightened*" when so raised. In a *lengthened* drain the increase in length necessary per foot in height of formation $= 2 \times$ ratio of slopes ($m = 1\frac{1}{2}$ foot, the ratio here adopted), or $2m$ (H′ − H), will be the total increase in length; where H′ = formation height of bank, H = tabular formation height of drain selected for elongation.

SLAB DRAINS.

41. *Slab drains*, except in the case of those of only 1 foot span, are designed with splayed wings, the face planes of which join the abutments at 6 inches from their corners. Hence, the distance from the face of the wing at base to the back of the abutment, on which depends the dimensions of the triangle at the back of the wing = y = 1·5. The thickness of the slab covers is invariably assumed to be 6 inches; and the height of the formation coincides with the top of these slabs, hence the depth of the road covering over the slabs should, at the *sides*, be 9 inches.

1 Foot Slab Drain.

The wings of this description of drain are merely productions of the abutments sloped off, as shown in the special wing plans of this drain; and therefore the general tables of wings of drains do not answer this particular case. Small drains of this sort are seldom used except to carry across the road some such water-courses as those leading from rayats' wells to their fields.

1½ Foot Slab Drain.

This drain is useful in discharging the catch-waters at intervals across the road. The abutments are given as 2 feet thick, because it is difficult to build sound work in rubble (if of any considerable height) when the thickness of the walling is less than this. Hence in *brickwork* the walls may be reduced to 18 inches in thickness.

The piers of this and all other drains are supposed to be of superior masonry; they are kept thin purposely in order that there may be as little obstruction as possible to the flow of the water.

2, 2½ and 3 Feet Slab Drains,

are ordinary cross drains for small nullahs. y (*see* Appendix,) = 1·5.

CULVERTS.

42. Also have splayed wings and y = 1·25.

The inverts are similar to the arches of the segmental drains, *i. e.* the versed sines are $\frac{1}{5}$th of the spans.

The examples given are

3, 4, 5, 6, 8 AND 10 FEET CULVERTS,

which are applicable to ordinary nullahs. When inverts and aprons are used, the depth of foundations may be somewhat reduced.

The *centres* of 3, 4 and 5 feet culverts are to be of "mud and stone" filling up the archway; and this is to be supported on cross girders [as shown in *Fig.* 5, *Plate* XXXVI.] Centres of those of 6 and 8 feet to be of "mud and stone," supported on trusses [as shown in *Figs.* 6 and 7].

The centres of 10 feet culverts to be "framed" as shown in the drawing of the culvert, and is to be lowered by sand-boxes or wedges.

43. EXPLANATION AND USE OF TABLES.—Table I., Part I., gives the quantities of work in any drain of a design similar to those of the average plans for the several heights of formation—H in *drains*, the level of the top of extrados of the arching.

Example of method by which Table I. has been constructed:—

Quantities in a slab drain, 3 feet span, in a bank of 6 feet formation height.

	SINGLE SPAN.					ADDITIONAL SPAN.			
	Estimate, cubic feet.	Heightening. No. of feet.	Heightening. Cubic feet in one.	Wings for 6 feet (Tab.).	Tabular number.	Estimate, cubic feet.	Heightening. No. of feet.	Heightening. Cubic feet in one.	Tabular number.
Foundations, Excavating, cubic feet, ...	228	+ ..	+	271	499	147	..		147
„ Filling in, cubic feet, ...	„	..		„	499	„	..		147
Superstructure,* cubic feet, ..	374·12†	+ 1·5×88	+	284	791	196·42†	+ 1·5×45·73	×	266‡
Slabs, superficial feet, ...	66	..		..	66	66	..		66
Coping, running feet, ...	15	..		..	15	10	..		10
Invert or paving, ...	46	..		..	46	46	..		46

44. In framing estimates of road masonry by this Table, two methods may be adopted, the more accurate of which is as follows:—

* The item "superstructure" in the Table, includes wings, cutwaters, headwalls, spandrils, backing to arching; that is to say, all masonry except foundations, slabs, arching, paving, parapets, copings and cornices.

† In calculating the Table, when the estimate quantities contained a fraction of a cubic foot, the *next greatest* integer has been taken; as for example, 375, and 197, instead of the numbers above.

‡ But in the case of fractions in the resulting number the *nearest* integer is entered; as for example, 266 is the Tab. No. instead of 265·595; the calculation being 197 + (1·5× 45·73) = 265·595.

The plans and sections of a road being before us we decide on the waterway and height of formation, for each water-course; and frame a list which may be tabulated, as in the form in this Art. (at page 358).

In this form the first column is the consecutive numbers from the plans; 2nd column is the sort of drain, showing the number of openings required; 3rd column is the height of formation.

From this, by Table I., we frame the second division of the form. In this division we enter headings for every description of work, and show—first, the quantities in a single span, and then the number of additional openings or spans, which we multiply into the tabular quantities for one additional span—taken also from Table I.; this product added to the 1st item gives the totals for each description of work, respectively. This process we repeat for each drain as in example, and we obtain the total cost of small masonry works of the given road, which may be carried into the recapitulation of the estimate.

Extras, such as "copings on wings," are got from other Tables (C); this item, as it is not necessary to *all* drains, is not entered in Table I. The rate for aprons and inverts should include any excavations necessary in laying them.

ESTIMATE of Masonry in Cross Drainage of Road from_____ to_____

BREADTH OF ROADWAY, 20 FEET.

LIST OF DRAINS.			QUANTITIES FROM TABLE I.																					
Number on plan or section.	Description of Drain.	Formation height.	Excavation of foundations.				Filling in foundations.				Superstructure.				Slabs or arches.			Slabs.	Arching.	Parapets.			Inverts and Aprons.			
			Single opening.	Additional spans.		Total cub. ft.	Single opening.	Additional spans.		Total cub. ft.	Single opening.	Additional spans.		Total cub. ft.	Single opening.	Additional spans.		Total sup. ft.	Total cub. ft.	Single opening.	Additional spans.		Total run. ft.	Single opening.	Additional spans.		Total sup. ft.
			c. ft.	No.	c. ft. in one.		c.ft.	No.	c.ft. in one.		c. ft.	No.	c.ft. in one.		quantity.	No.	content in one.			r.ft.	No.	r.ft. in one.		s. ft.	No.	s. ft. in one.	
1	Single span of 2 feet Slab drain,	4	383 + 0			383	As in excavation.			383	440 + 0			440	44 + 0			44	..	....		..	$\left\{\begin{matrix}23^{*}\\94\end{matrix}\right\}$ + 0			117
2	Double „ 3 feet „ „	4	389 + (1×147)			536	„			536	443 + (1 × 174)			617	66 + (1 × 66)			132	..	....		..	$\left\{\begin{matrix}46^{*}\\104\end{matrix}\right\} + \left(1 \times \frac{46}{55}\right)$			251
3	Single „ 3 feet Culvert } Segmental,† }	5	44			442	„			442	589 + 0			589	65 + 0			..	65	....		..	76‡ + 0			76
4	Four „ 8 feet „ S. C.	13	1,109 + (3§ × 147)			1,550	„			1,550	3,229 + (3 × 506)			4,747	311 + (3 × 311)			..	1,244	29 + (3 × 20)		89	not required			..
5	Double „ 5 feet „ S. C.,	15	1,321 + (1 × 164)			1,485	„			1,485	4,327 + (1 × 633)			4,960	208 + (1 × 208)			..	416	21 + (1 × 14)		35	$\left\{\begin{matrix}127‡\\1276\end{matrix}\right\} + \left(1 \times \frac{127}{304}\right)$			1,838
&c.,	&c., &c.,																									
	Total, Quantities, ..					4,896	....			4,396	....			11,353	....			176	1,725	....		124	....			2,282
	Rate ..						per				per				per					per			per			per
	Total Cost, Rs., ..																									

Grand total cost of masonry, Rs._____

* { Upper figure is the invert from Table I.
{ Lower „ „ aprons „

‡ This drain required only an invert, not an apron.

† In this case the culvert has a *segmental arch*, and the quantity in superstructure, becomes 566 + 49 = 615 arching
„ 98 − 33 = 65

§ This number is always one less than the number of spans.

45. Had the breadth of road exceeded the tabular breadth (20 feet) by x feet, then x times the quantities in one foot of the length of bridge—taken from Table II.—should be added to the respective quantities of single and additional spans. For example, Nos. 3 and 4, in the above form, would have become in the excavation of foundations and superstructure, when the road was 22 feet, as follows :—

List &c.	Excavation of foundations.							Superstructure.							&c.
	Single opening.			Additional spans.				Single opening.			Additional spans.				
Number on plan	From Table I. Quantity.	No. of extra feet = x = 2.	From Table II. Quantity.	No. of spans.	From Table I. Quantity.	x = No. of extra feet = 2.	From Table II. Quantity.	Total cubic feet.	From Table I. Quantity.	x = 2.	From Table II. Quantity.	From Table I. Quantity.	x = 2.	From Table II. Quantity.	Total cubic feet.	
3	442	× (2 + | 10)	+ 0	..	..	..	462	539	+ (2 × 16·62)	+	0		..	622	
4	1109	× (2 + | 13)	+ 3	{ 147	+ (2 × 6)	}	1612	3229	+ (2 × 59·63)	+ 3	{ 506	+ (2 × 20·5)	}	4989	&c.
	&c.								&c.							

46. The other method, mentioned in para. 44, is when several drains of the same dimensions, that is, of the same spans and number of spans, occur in the list, to take the mean of their formation heights; and consider an average drain of their mean height to answer for all cases; the quantities in this to be entered in the Form, and multiplied by the number of them that there may be. This method is evidently not so accurate as the former.

47. Instructive comparisons may be made by means of the Tables I., II., for instance, comparison of the relative cost of raising and lengthening of drains; which solves the question often propounded whether it is cheaper to run a low culvert through a bank till its ends catch the slope at the height of the extrados; or to build a taller drain, at the same place, of such height that the parapets will fence the road.

48. *Leaving waterway out* of *consideration* it will be found that it is much more economical to "*lengthen*" than to "*heighten*" a drain.

49. Table II., Part I., gives the quantities of work in *one foot of the length* of any drain, for various heights of formations, calculated from the estimates of each structure.

It is used in obtaining the quantities in drains of lengths differing from that of the average plans—which is 22 feet for a 20 feet roadway.

The several quantities in this Table, multiplied by the difference of lengths, is to be added to (or subtracted from as the case may be) those of Table I. Example of method by which Table II. has been constructed :—

Quantities in one foot long of a 3 feet slab drain in a 6 feet bank.

	Single opening.			Additional spans.		
	From Estimate.	For heightening.	Tabular No.	From Estimate.	For heightening.	Tabular No.
Foundations, Excavation, ...	10 +	0	= 10	6 +	0	= 6
,, Filling in, ...	do. +		= 10	do.		= 6
Superstructure, ...	16 +	(1·5 × 4)	= 22	8 +	(1·5 × 2)	= 11
Slabs, ...	3 +	0	= 3	3 +	0	= 3
Inverts, ...	2 +	0	= 2	2 +	0	= 2

Example of use of Table II. Quantities in 2 feet long of the above drain ?

	Single opening.			Additional spans.		
	Tabular No.	Length.	Total.	Tabular No.	Length.	Total.
Foundations, Excavation, ...	10 ×	2	= 20	6 ×	2	= 12
,, Filling in, ...	do.		= 20	do.		= 12
Superstructure, ...	22 ×	2	= 44	11 ×	2	= 22
Slabs, ...	3 ×	2	= 6	3 ×	2	= 6

and, if we require the quantities of the above drain where the breadth of road is 22 feet, we add the above quantities to the totals of the same drain in Table I. [*See* example, page 359, Art. 45].

50. Example of a Lengthened Culvert or Tunnel :—Suppose a ravine of section [as in *Fig.* 9] to be crossed.

The breadth of nullah, *e. g.* = 8 feet, and we require 75 superficial feet of waterway as a maximum. To cross this river on a level a height of formation = 40 feet would be required, and to build an 8 feet culvert of this height, where we only want 75 feet of waterway would be absurd. From Table of 8 feet drains, we find that one of 12 feet formation height gives 81 feet area of waterway, this would be therefore a suitable

drain, and by rule [in page 355, Art. 40] its increased length would be $2\,m\,(H' - H) = 3 \times (40 - 12) = 84$, hence the quantities in Table I. for an 8 feet drain, of formation height = 12, are to be increased by the quantities for a similar drain in Table II., multiplied by 84; thus—

Excavation of foundations,	1,017 + (84 × 13),	...	=	2,109 cubic feet.
Filling in of ditto,	do.,	...	=	2,109 ,,
Superstructure,	2,779 + (84 × 54·13),	.	=	7,326 ,,
Arching, ...	311 + (84 × 14·13),	.	=	1,498 ,,
Impost, ...	12 + 0	...	=	12 running feet.
Coping, ...	30 + 0	...	=	30 ,,
Invert, ...	203 + (84 × 8·8),	...	=	942 superficial ft.
Centering (mud and stone),*	533 + (84 × 25·13),	.	=	2,664 cubic feet.
Aprons (lower end) Table C,	$\frac{998}{2}$ + 0	...	=	499 superficial ft.

* Here it would probably be advisable to use a trussed centre; and as the drain would, of course, be built in short lengths of about 20 feet, the quantities of the centerings are got from foot-note in Table I., thus:—

Wood work, 22·35 cubic feet; iron, 1 lb; rafters, No. 35; mud and stone, 156 cubic feet.

If built all at once, however, the extra number of ribs required would be $\frac{84}{5·5} = 16$, and this multiplied by 4·47, would be the additional quantity of timber = 71·5 cubic feet. So also rafters = $24 \times 84 = 2016$ running feet, and mud and stone = $7·1 \times 84 = 596·4$ cubic feet.

TABLE I. PART I.

QUANTITIES IN DRAINS AND CULVERTS

ON

ROADS 20 FEET WIDE,

CALCULATED FOR

ALL FORMATION HEIGHTS.

LENGTH OF ABUTMENT, 22 FEET.

20 FEET ROADS.

1, 1½, 2, 2½, 3, Feet Slab Drains.

Formation Heights.	Single Span. Excavation } Foundations, Filling in } Cubic feet. 1 2	Superstructure, Cubic feet.* 3	Slabs, Superficial feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons,† Superficial feet. 9	Formation Heights.	Each Additional Span. Excavation } Foundations, Filling in } Cubic feet. 1 2	Superstructure, Cubic feet. 3	Slabs, Superficial feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons, Superficial feet. 9	Cut-water caps, No. 10	Area of Waterway, Superficial feet.
	S=4								**1 Foot Slab Drain.** Heightened.								S′=2		
1·5	124	85	22	..	..	6	..	..	1·5	53	28	22	..	..	4	..	..	1	1·0
2‡	136	125		..	..		..	..	2‡	56	39		..	..		..	..		1·5
3	160	202		..	..		..	..	3	62	61		..	..		..	..		2·0
	S = 5·5								**1½ Foot Slab Drain.** Heightened.								S′ = 3		
2	294	176	33	..	..	12	11·5	26	2	120	59	33	..	..	6	10	15	1	2·2
3‡	336	299		..	..			52	3‡		93		..	..			24		3·7
4	383	439		..	..			88	4		127		..	..			33		5·2
5	436	602		..	..			134	5		161		..	..			42		6·7
	S = 6								**2 Feet Slab Drain.** Heightened.								S′ = 3·5		
2	294	177	44	..	..	13	23	28	2	120	60	44	..	..	7	23	18	1	3
3	336	300		..	..	13		56	3		94		..	..			28		5
3·5‡	360	368		..	..	13		78	3·5‡		111		..	..			33		6
4	383	440		..	..	13		94	4		128		..	..			39		7
5	436	603		..	..	13		140	5		162		..	..			49		9
6	493	788		..	..	13		196	6		196		..	..			60		11
7	555	998		14	13	14		260	7		230		7	7			70		13
	S = 6·5								**2½ Feet Slab Drain.** Heightened.								S′ = 4·25		
2	294	178	55	..	..	14	35	30	2	134	74	55	..	..	8·5	35	22	1	3·7
3	336	301		..	..	14		60	3		113		..	..			34		6·2
4‡	383	441		..	..	14		100	4‡		151		..	..			47		8·7
5	436	604		..	..	14		148	5		190		..	..			60		11·2
6	493	789		..	..	14		204	6		228		..	..			72		13·7
7	555	999		15	14	15		270	7		267		8·5	8·5			85		16·2
8	621	1238		15	14	15		346	8		305		8·5	8·5			97		18·7
	S = 7								**3 Feet Slab Drain.** Heightened.								S′ = 5		
3	312	303	66	..	..	15	46	64	3	147	128	66	..	..	10	46	40	1	7·5
4	389	443		..	..	15		104	4		174		..	..			55		10·5
4·5‡	414	522		..	..	15		113	4·5‡		197		..	..			62		13·5
5	442	606		..	..	15		154	5		220		..	..			70		16·5
6	499	791		..	..	15		212	6		266		..	..			85		19·5
7	561	1001		15	15	16		280	7		311		..	..			100		22·5
8	627	1240		15	15	16		356	8		357		10	10			115		25·5
9	699	1509		15	15	16		442	9		403						130		28·5

* The item "superstructure" includes "wings and abutments" over foundation level, backing to arches, counterforts, head walls.

† No deduction for cut-water, if made equal for 1½ and 2 feet drains; 2·5 superficial feet for 2½ feet; 3·4 for 3 feet = 4·5 superficial feet.

‡ Quantities taken from detailed estimates of average plan of these heights.

Invert and Aprons are included in the foundations of 1 foot slab drains.

20 FEET ROADS.

3 and 4 Feet Culverts.

Formation Heights.	Single Span. Excavation, Foundations, Filling in, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons,* Superficial feet. 9	Mud and stone,† Centres. Cubic feet. 10
3	340	260		..	..	16		68	
4	388	402		..	..	16		110	
5‡	442	566		..	..	16		162	
6	499	752	98	..	..	16	76	222	78
7	562	965		..	..	17		290	
8	630	1206		17	16	17		368	
9	702	1477				17		456	
10	779	1778				17		552	

Formation Heights.	Each Additional Span. Excavation, Foundations, Filling in, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons,* Superficial feet. 9	Cutwater caps, Superficial feet, No. 10	Mud and stone,* Centres. Cubic feet. 11	Area of Waterway, Superficial feet.
3		73		..	..			36			5
4		112		..	..			52			8
5‡		152		..	..			67			11
6	134	192	98	..	..	9·5	76	81	1	78	14
7		232		..	..	9·5		95			17
8		271		9·5	9·5	9·5		109			20
9		311		9·5	9·5	9·5		123			23
10		351				9·5		149			26

S = 7 — **3 Feet Culvert.** — S′ = 475.

Quantities for "Heightened" Semicircular Arches.

Differences for Segmental Arches.

All	None	+23	−33	None	−50	All	None	+34·	−33	None	−50	+·4

S = 8 — **4 Feet Culvert.** — S′ = 5·75

Quantities for "Heightened" Semicircular Arches.

Formation Heights.	Single Span. Excavation, Foundations, Filling in, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons,* Superficial feet. 9	Mud and stone,† Centres. Cubic feet. 10
4	338	393		..	..	18		122	
5	442	557		..	..	18		176	
6‡	499	743		..	..	18		238	
7	562	956	123	..	..	18	102	310	139
8	630	1197		19	18	19		392	
9	702	1468				19		482	
10	779	1769				19		580	
11	862	2108				19		688	

Formation Heights.	Each Additional Span. Excavation, Foundations, Filling in, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Cornice, Running feet. 5	Parapets, Running feet. 6	Coping, Running feet. 7	Invert, Superficial feet. 8	Aprons,* Superficial feet. 9	Cutwater caps, Superficial feet, No. 10	Mud and stone,* Centres. Cubic feet. 11	Area of Waterway, Superficial feet.
4		107		..	..			46			11
5		147		..	..			63			15
6‡		187		..	..			81			19
7	134	227	123	..	..	11·5	102	97	1	139	23
8		267		11·5	11·5	11·5		115			27
9		306				11·5		132			31
10		346				11·5		149			35
11		386				11·5		167			39

Differences for Segmental Arches.

All	None	+ 19	−40	None	−90	All	..	+34	−40	None	−90	+1·

* Both ends, no deduction for cutwater in additional span; if made equal for { 3 feet culverts / 4 feet do. } 3·4 superficial feet.

† Filling up whole arch opening over springing, supported by cross timbers, as in *Fig.* 5.

‡ Quantities in average plan of this height taken from detailed estimate.

20 FEET ROADS.

5 Feet Culverts.

Formation Heights.	Single Span.											Formation Heights.	Each Additional Span.												Area of Waterway, Superficial feet.
	Excavation, } Foundations, Filling in, } Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapet, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Mud and stone,† } Centres. Cubic feet.			Excavation, } Foundations, Filling in, } Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapet, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Culvwater caps, No.	Mud and stone, } Centres. Cubic feet.		
	1 2	3	4	5	6	7	8	9	10	11			1 2	3	4	5	6	7	8	9	10	11	12		
5	465	564			..	..			196			5		144			..	..			98				17
6	522	761			..	..			264			6		189			..	..			119				22
7‡	585	985							340			7‡		235							140				27
8	653	1237							426			8		281							161				32
9	725	1519							520			9		326							182				37
10	802	1831							624			10		372							203				42
11	885	2181	208	10	22	21	22	137	736	216		11	147	418	209	12	14	14	14	127	224	1	216		47
12	971	2568							858			12		464							245				52
13	1063	2996							988			13		509							266				57
14§	§ 1220	§ 3782							1128			14‖	164	587‖							287				62
15§	§ 1321	§ 4327							1276			15‖	164	633‖							308				67

S = 9·5. **5 Feet Culvert.** S' = 7

Quantities for "Heightened" Semicircular Arches.

Differences for Segmental Arches.

All	None	+52	—70	None	+140	All	None	+59	—70	None.	—140	+1·4

*, †, ‡, *See* Notes to 3 and 4 feet Culverts. Deduction = 4·5 Superficial feet.
§ Counterforts to height (H — 3·5) added to back of abutments.
‖ Plinth 5 feet high, projecting 3 inches, added to pier.

Note :—Quantities in a Trussed Centre (*Fig.* 5).

Wood work.	7·5 cubic feet	in whole centre,	1·5 Cubic feet in one rib.
Iron work.	·5 lbs.	,,	·1 lb.
Rafters,	220 Running feet,	,,	10 Running feet in one foot long.
Mud and stone,	216 Cubic feet,	,,	9·8 Cubic feet ,,

20 FEET ROADS.

6 Feet Culverts.

Formation Heights.	Single Span. Excavation, Filling in, } Foundations, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet 4	Impost, Running feet. 5	Cornice, Running feet. 6	Parapets, Running feet. 7	Coping, Running feet. 8	Invert, Superficial feet. 9	Aprons,* Superficial feet. 10	Mud and Stone,† Cubic feet. } Centres. 11	Formation Heights.	Each Additional Span. Excavation, Filling in, } Foundations, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Impost, Running feet. 5	Cornice, Running feet. 6	Parapets, Running feet. 7	Coping, Running feet. 8	Invert Superficial feet. 9	Aprons,* Superficial feet. 10	Cutwater Caps, No. 11	Mud and Stone, Cubic feet. } Centres. 12	Area of Waterway, Superficial feet.
S = 11																							S′ = 8
6 Feet Culvert.																							
Quantities for (Heightened) Semicircular Arches.																							
6	545	805			...	...			290		6		189			...	...			136			26
7	608	1040							370		7		234							160			32
8‡	676	1303							460		8‡		280							184			38
9	748	1596							560		9		226							208			44
10	825	1919							668		10	147	372							232			50
11	908	2280							784		11		417							256			56
12	994	2678	242	10	26	25	26	152	912	311	12		463	242	12	16	16	16	152	280	1	311	62
13	1086	3117							1046		13		509							304			68
14	1183	3599							1190		14		555							328			74
15§	1344	4455							1342		15 ‖	164	632							352			80
16§	1450	5059							1504		16 ‖	164	678							376			86
17§	1561	5711							1676		17 ‖	164	723							400			92
18§	1677	6419							1856		18 ‖	164	769							424			98
Differences for Segmental Arches.																							
All.	None.	+55	−80	None						−202	All.	None	+63	−80	None.							−202	+2

*, †, ‡. *See* Notes to 3 and 4 Feet Culverts. Deduction = 4·5 Superficial feet.
§ Counterforts and Height (H—4) added at back of Abutments.
‖ Plinth 5 feet high, projecting 3 inches, added to pier.
NOTE :—Quantities in a Trussed Centre (*Fig.* 6.)
Wood Work, 15·6 Cubic feet in whole Centre, 3·12 Cubic feet in one rib.
Iron Work, ·75 lbs. ,, ·2 lbs. ,,
Rafters, 440 Running feet ,, 20 Running feet in one foot long.
Mud and Stone, 88 Cubic feet ,, 4 Cubic feet ,,

20 FEET ROADS.

8 Feet Culverts.

Formation Heights.	Single Span.										Formation Heights.	Each Additional Span.											Area of Waterway, Superficial feet.
	Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapets, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Mud and Stone,† } Centres. Cubic feet.		Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapets, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Cutwater Caps, No.	Mud and Stone, Cubic feet. } Centres.	
	1 2	3	4	5	6	7	8	9	10	11		1 2	3	4	5	6	7	8	9	10	11	12	
	S = 13·5		8 Feet Culvert.									S′ = 10											
	Quantities for (Heightened) Semicircular Arches.																						
6	568	840	..	..	..	..	29		332		6		186				..	..		170			33
7	631	1086							420		7		232							200			41
8	699	1360							518		8		278							230			49
9	771	1664							624		9		324							260			57
10‡	858	1998							740		10‡		369							290			65
11	931	2370							864		11		415							320			73
12	1017	2779							998		12		461							350			81
13	1109	3229	311	12	30	29	30	203	1140	553	13	147	506	311	12	29	20	20	203	380	1	553	89
14	1206	3722							1292		14		552							410			97
15	1307	4259							1452		15		598							440			105
16	1413	4844							1622		16		644							470			113
17§	1584	5837							1800		17‖	164	721							500			121
18§	1700	6556							1988		18‖	164	767							530			129
19§	1819	7324							2018		19‖	164	813							560			137
20§	1945	8153							2390		20‖	164	859							590			145
	Differences for Segmental Arches.																						
All.	None	+55	−102			None		−359	..		All.	None	+55	−102			None.			−359			+3

*, †, ‡ *See* Notes to 3 and 4 feet Culverts. Deduction = 4·5 Superficial feet.
§ Counterforts to (Height H—5) added to back of Abutments.
‖ Plinth 5 feet high projecting 3 inches added to pier.

Note:—Quantities in a Trussed Centre (*Fig.* 7).

Wood Work, 22·4 Cubic feet	in whole Centre.	4·5 Cubic feet	in one rib.
Iron Work, 1 lb.	,,	·2 lb.	,,
Rafters, 528 Running feet	,,	24 Running feet	in one foot long.
Mud and Stone, 156 Cubic feet	,,	7·1 Cubic feet	,,

20 FEET ROADS.

10 Feet Culverts.

Formation Heights.	Single Span.										Centres.				Formation Heights.	Each Additional Span.											Area of Waterway, Superficial feet.
	Excavation, } Foundations, Filling in, } Cubic feet.		Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapets, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Wood Work,¶ Cubic feet.	Iron Work, lbs.	Sand Boxes, No.	Removals, No.		Excavation, } Foundations, Filling in, } Cubic feet.		Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Cornice, Running feet.	Parapets, Running feet.	Coping, Running feet.	Invert, Superficial feet.	Aprons,* Superficial feet.	Cutwater Caps, No.	Centering.	
	1	2	3	4	5	6	7	8	9	10	1	2	3	4		1	2	3	4	5	6	7	8	9	10	11	12	
6	568		773				..	..	33	..	366				6			197				..	..		212			37
7	631		1019								460				7			256							250			47
8	699		1293								563				8			315							288			56
9	771		1597								676				9			374							326			67
10	858		1931								777				10			433							363			77
11	931		2303								928				11			492							400			87
12‡	1017		2712								1047				12‡			550							438			97
13	1109		3162								1216				13			609							475			107
14	1206		3655								1353				14			668							513			117
15	1307		4192								1549				15			727							550			127
16	1413		4777								1695				16			786							588			137
17§	1584		5733								1900				17‖			975							625			147
18§	1700		6452								2073				18‖			1033							663			157
19§	1819		7220								2296				19‖			1092							700			167
20§	1945		8049								2507				20‖			1151							738			177
				486	12	34	33	34	253		109	1·2	10	1		300			486	13	25	25	25	253		1	Same as for single span.	
All.	None		+100	—156	None.						—27	None.			All.	None		+92	—156	None.					..		+4·5

S=15·5 — 10 Feet Culvert. — S′=12·5

Quantities for (Heightened) Semicircular Arches.

Differences for Segmental Arches.

*, †, ‡. *See* Notes to 3 and 4 feet Culverts. Deduction=5 Superficial feet.

§ Counterforts to Height (H — 6·25) added to back of Abutments.

‖ Plinth 5 feet high, projecting 3 inches, added to pier.

¶ Wood work made up of 46 Cubic feet in ribs, and 63 Cubic feet in Laggings and tie planks over sand boxes. Segmental differences = — 10 and — 17 Cubic feet, respectively.

TABLE II. PART I.

QUANTITIES IN A VERTICAL SECTION

OF

1 FOOT IN LENGTH

OF DRAINS AND CULVERTS

CALCULATED FOR

ALL FORMATION HEIGHTS.

Used as Supplementary to Table I. for Increased Lengths of Drains, &c.

LENGTH OF ABUTMENTS, 1 FOOT.

1 FOOT IN LENGTH OF DRAINS.

1, 1½, 2, 2½, 3, Feet Slab Drains.

Formation Heights.	Single Span.				Formation Heights.	Each Additional Span.			
	Excavation, Foundations, Filling in, Cubic feet.	Superstructure, Cubic feet.	Slabs, Superficial feet.	Invert, Superficial feet.		Excavation, Foundations, Filling in, Cubic feet.	Superstructure, Cubic feet.	Slabs, Superficial feet.	Invert, Superficial feet.
	1 2	3	4	5		1 2	3	4	5
1 Foot Slab Drain.									
Heightened.									
1·5		3·0			1·5		1·0		
2*	4	4·5	1	In foundations.	2*	2	1·5	1	
3		7·5			3		2·5		
1½ Foot Slab Drain.									
Heightened.									
2		6			2		2·25		
3*	10	10	1·5	·5	3*	5	3·75	1·5	·5
4		14			4		5·25		
5		18			5		6·75		
2 Feet Slab Drain.									
Heightened.									
3		10			3		3·75		
3·5*		12			3·5*		4·50		
4		14			4		5·25		
5	10	18	2	1	5	5	6·75	2	1
6		22			6		8·25		
7		26			7		9·75		
2½ Feet Slab Drain.									
Heightened.									
3		10			3		4·38		
4*		14			4*		6·13		
5		18			5		7·88		
6	10	22	2·5	1·5	6	5·5	9·63	2·5	1·5
7		26			7		11·38		
8		30			8		13·13		
3 Feet Slab Drain.									
Heightened.									
3		10			3		5		
4		14			4		7		
4·5*		16			4·5*		8		
5	10	18	3	2	5	6	9	3	2
6		22			6		11		
7		26			7		13		
8		30			8		15		
9		34			9		17		

* The quantities from Estimates for this height.

1 FOOT IN LENGTH OF DRAINS.

3 and 4 Feet Culverts.

3 Feet Culvert.

QUANTITIES FOR (HEIGHTENED) SEMICIRCULAR ARCHES.

Formation Heights.	Single Span. Excavation, Foundations, Filling in, Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Invert, Superficial feet. 5	Centres. Mud and stone, Cubic feet. 6	Formation Heights.	Each Additional Span. Excavation, Foundations, Filling in. Cubic feet. 1 2	Superstructure, Cubic feet. 3	Arching, Cubic feet. 4	Invert, Superficial feet. 5	Centres. Mud and stone, Cubic feet. 6
3	10	7·42	4·42	3·3	3·5	3	5·5	2·54	4·42	3·3	3·5
4		11·42				4		4·29			
5*		15·42				5*		6·04			
6		19·42				6		7·79			
7		23·42				7		9·54			
8		27·42				8		11·29			
9		31·42				9		13·04			
10		35·42				10		14·79			

DIFFERENCES FOR SEGMENTAL ARCHES.

All	None	+1·2	—1·52	None	—2·26	All	None	+2·24	—1·52	None	—2·26

4 Feet Culvert.

QUANTITIES FOR (HEIGHTENED) SEMICIRCULAR ARCHES.

4	10	10·73	5·6	4·4	6·3	4	5·5	3·92	5·6	4·4	6·3
5		14·73				5		5·67			
6*		18·73				6*		7·41			
7		22·73				7		9·17			
8		26·73				8		10·92			
9		30·73				9		12·67			
10		34·73				10		14·42			

DIFFERENCES FOR SEGMENTAL ARCHES.

All	None	+·97	—1·8	None	—4·1	All	None	+1·54	—1·8	None	—4·1

*Quantities from Estimates for this height.

1 FOOT IN LENGTH OF DRAINS.

5 Feet Culverts.

Formation Heights.	Single Span.					Formation Heights.	Each Additional Span.				
	Excavation, Filling in, Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres. Mud and stone, Cubic feet.		Excavation, Filling in, Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres. Mud and stone, Cubic feet.
	1 2	3	4	5	6		1 2	3	4	5	6
5	11	14·55	9·43	5·5	9·82	5	6	5·26	9.43	5·5	9·82
6		19·05				6		7·26			
7*		23·55				7*		9·26			
8		28·05				8		11·26			
9		32·55				9		13·26			
10		37·05				10		15·26			
11		41·55				11		17·26			
12		46·05				12		19·26			
13		50·55				13		21·26			
14		55·05				14†		25·76			
15		59·55				15		27·76			
All	None	+2·65	−3·16	None	−6·38	All	None	+2·65	−3·19	None	−6·38

5 Feet Culvert.

Quantities for (Heightened) Semicircular Arches.

Differences for Segmental Arches.

* Quantities for this height from Estimates.
† Plinth 5 feet high, projecting 3 inches for drains of this height and over.

1 FOOT IN LENGTH OF DRAINS.

6 Feet Culverts.

Formation Heights.	Single Span.					Formation Heights.	Each additional Span.				
	Excavation, Filling in, Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres. Mud and stone, Cubic feet.		Excavation, Filling in, Foundations, Cubic feet.	Superstructure Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres. Mud and stone, Cubic feet.
	1 2	3	4	5	6		1 2	3	4	5	6

6 Feet Culvert.

Quantities for (Heightened) Semicircular Arches.

6		20·54				6		7·03			
7		25·54				7		9·03			
8*		30·54				8*		11·03			
9		35·54				9		13·03			
10		40·54				10		15·03			
11		45·54				11		17·03			
12	12	50·54	11	6·6	14·2	12	6	19·03	11	6·6	14·2
13		55·54				13		21·03			
14		60·54				14		23·03			
15		65·54				15		25·03			
16		70·54				16†	7	29·53			
17		75·54				17	7	31·53			
18		80·54				18	7	33·53			

Differences for Segmental Arches.

All.	None	+2·86	−3·64	None	−9·25	All.	None	+2·8	−3·64	None	−9·25

*,†. *See* Notes to 5 feet Culvert.

1 FOOT IN LENGTH OF DRAINS.

8 Feet Culverts.

Formation Heights.	Single Span.					Each Additional Span.					
	Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres: Mud and Stone, Cubic feet.	Formation Heights.	Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres: Mud and Stone, Cubic feet.
	1 2	3	4	5	6		1 2	3	4	5	6

8 Feet Culvert.

Quantities for (Heightened) Semicircular Arches.

6	13	21·13	14·13	8·8	25·13	6	6	6·5	14·13	8·8	25·13
7		26·63				7		8·5			
8		32·13				8		10·5			
9		37·63				9		12·5			
10*		43·13				10*		14·5			
11		48·63				11		16·5			
12		54·13				12		18·5			
13		59·63				13		20·5			
14		65·13				14		22·5			
15		70·63				15		24·5			
16		76·13				16		26·5			
17		81·63				17†	7	31			
18		87·13				18	7	33			
19		92·63				19	7	35			
20		98·13				20	7	37			

Differences for Segmental Arches.

All	None.	+2·98	—4·65	None	—16·5	All	None	+2·4	—4·65	None	—16·5

*, †, *See* Notes to 5 feet Culvert.

1 FOOT IN LENGTH OF DRAINS.

10 Feet Culverts.

Formation Heights.	Single Span.								Formation Heights.	Each Additional Span.				
	Excavation, Foundations, Filling in, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres.					Excavation, Foundations, Filling in, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Invert, Cubic feet.	Centres
					Wood work in rib, Cubic feet.	Do. in planking and laggings, Cubic feet	Iron work, lbs.	Sand Boxes, No.						Framed.
	1 2	3	4	5	1		2	3		1 2	3	4	5	6

10 Feet Culvert.

Quantities for (Heightened) Semicircular Arches.

6	13	27·14	22·09	11	± 46·5 for every 5·5 feet ± in length.	2·85 for every foot ± in length.	·6 for every 5·5 feet ± in length.	2 for every 5·5 feet ± in length.	6	12	6·36	22·09	11	Same as for single span.
7		32·64							7		8·86			
8		38·14							8		11·36			
9		43·64							9		13·86			
10		49·14							10		16·36			
11		44·64							11		18·86			
12*		50·14							12*		21·36			
13		55·64							13		23·86			
14		61·14							14		26·36			
15		66·64							15		28·86			
16		72·14							16		31·36			
17		77·64							17†	13·5	36·36			
18		83·14							18	13·5	38·86			
19		88·64							19	13·5	41·36			
20		94·64							20	13·5	43·86			

Differences for Segmental Arches.

All	None	+5·4	−7·09	None	−10·3	−·78	None	All	None	+3·8	−7·09	None	−10·3

*, †, *See* Notes to 5 feet Culverts.

APPENDIX TO PART I.

PART I.—WING WALLS.

THE calculations of the contents, &c., of wing-walls, are tabulated in Tables A. and B., and are arrived at as follows :—

A wing-wall may for convenience of calculation be divided into 2 parts: the wing proper, or the body of wing, that is to say, that part in front of the line of the face of the bridge; and the triangular based pyramid joining the shoulder of the wing proper to the abutment.

Owing to the figure of the walls, in calculating the contents of the *wing proper*, it will be most accurate to use skew areas; that is, areas parallel to the face of the bridge; and lengths perpendicular to the same.

With given ratio of slopes m, the perpendicular length will vary with the formation height $\therefore l = m\,H = H \cot \theta$, θ = angle of slope of bank with horizon. The skew breadths depend on the perpendicular breadths of wall, which we know by construction to be :—

breadth at top $t = 1{\cdot}25$; breadth at base $= t + r\,H = 1{\cdot}25 + \frac{H}{4}$,
and the angle of skew, $\phi°$, which we also know to be 45°,
$\therefore$ skew breadth at top $= t \sec \phi = 1{\cdot}25 \times 1{\cdot}414 = 1{\cdot}77$
„ „ at base $= B = t \sec \phi + rH \frac{\cos \beta°}{\cos (\phi° - \beta°)} = {\cdot}3175\ H + 1{\cdot}7675 = {\cdot}317\ H + 1{\cdot}77$ nearly.

$\therefore$ skew area $= A = \frac{H}{2}\left\{2\,t \sec \phi + \frac{rH \cos \beta}{\cos\,(\phi - \beta)}\right\} = \frac{{\cdot}317}{2}\ H^2 + 1{\cdot}77\ H$,
when angle β is found from equation $\tan \beta = \frac{rH}{l \sec \phi} = {\cdot}11785$, for unit of height,
r = batter of wall; H = height of wall; β = angle back of base of wall makes with face on plan = 6° 40′; $\phi°$ = angle of splay of wing = 45°: $\cos \beta = {\cdot}9933$; $\cos (\phi° - \beta°) = \cos 38°\ 30' = {\cdot}784$; the length along axis of wing $= L = l \sec \phi = 2{\cdot}121$ H.

The true mean, or "Prismoidal" area $= \frac{A + 4 \text{ middle } A + 0}{6} = A_p = {\cdot}0528\ H^2 + {\cdot}885$ H, and this multiplied by l = true content $= c = {\cdot}07925\ H^3 + 1{\cdot}3275\ H^2 = {\cdot}08H^3 + 1{\cdot}33\ H^2$ very nearly.

For the *Pyramid*, the area of base $= A'' = \frac{(B - Y)^2 \tan (\phi° + \beta°)}{2} = {\cdot}63\ (B - Y)^2$ where $(\phi + \beta°) = 51°\ 40'$; and Y the breadth from toe of wing on face to back of abutment, which is constant for each sort of drain; hence the *content* $= C'' = \frac{A'' H}{3}$.

The *foundations* of the *wing proper* are ·5 wider than the square breadths of the superstructure; therefore the skew breadth $B' = B + \cdot 5 \sec \phi = B + \cdot 707 = \cdot 317\ H + 2\cdot 5$, and the area $= A' = \cdot 238\ H^2 + 3\cdot 712\ H = \cdot 24\ H^2 + 3\cdot 7\ H$, and for walls 2 feet deep the content $= C' = 2A' = \cdot 48\ H^2 + 7\cdot 4\ H$, nearly.

The *foundations* of the *pyramid* $C'' = A'' \times 2$.

Tables A. and B. are used in constructing Table I., PART I., *vide* Art. 43, page 353.

EXAMPLES OF THE USE OF TABLES A. AND B.

Example 1 (*see* page 352, Art. 26). When a wing of 10 feet formation height is cut off at a point where it is 4 feet in height, to find its contents?

Superstructure, 212·3—26 = 186 cubic feet, (*see* Table B.)

Foundations, 221·9—37·4 = cubic feet, (*see* Table A.)

Example 2 (*see* page 352, Art. 27). Where the ground on which a wing is founded proves to be hard and should be sloped up (*vide Fig.* 8, *Plate* XXXVI.), to find the contents of the wing? Let $H = 19$, $x = 4 \therefore H - x = 15$.

For *superstructure*, the mean area is that due to the height H, for the end areas have not altered; the length is that due to $H - x$, hence, from table B., $A_p = 35\cdot 95$ and $l = 22\cdot 5 \therefore c = 35\cdot 95 \times 22\cdot 5 = 808\cdot 87$ cubic feet.

For *foundations*, the mean breadths are unaltered, therefore the breadth is that due to $H = 8\cdot 50$, and l as before $= 22\cdot 5$; the depth $= 2 \therefore c' = 8\cdot 5 \times 22\cdot 5 \times 2 = 382\cdot 5$ cubic feet.

TABLE A.—PART I.

DRAINS.

Foundations of Wing Walls.

Formation Heights.	Body of Wing.				Triangles at Shoulders of Wings.				Formation Heights.	Bodies and Triangles combined.	
	Breadth of base at shoulder parallel	Length perpendicular.	Area of one.	Cubic feet in one.	Slab drains $y = 1{\cdot}5$.		Culverts $y = 1{\cdot}25$.			Slab drains.	Culverts.
	To axis of road.				Area of one.	Cubic feet in one.	Area of one.	Cubic feet in one.		Cubic feet in four.	
H	B′	L.	A′	C′	A″	C″	A″	C″	H	4 (C′+C″)	
2	3·11	3	8·4	16·8	·5	1·1	·9	1·7	2	72	74
3	3·43	4·5	13·3	26·6	1·0	1·9	1·4	2·7	3	114	117
4	3·74	6	18·7	37·4	1·5	3·0	2·0	4·0	4	161	165
5	4·06	7·5	24·5	49·1	2·2	4·4	2·8	5·6	5	214	219
6	4·38	9	30·9	61·7	3·0	5·9	3·7	7·4	6	271	276
7	4·69	10·5	37·6	75·3	3·9	7·8	4·7	9·5	7	333	339
8	5·01	12	44·9	89·9	5·0	10·0	5·9	11·8	8	399	407
9	5·33	13·5	52·7	105·5	6·1	12·3	7·2	14·3	9	471	479
10	5·65	15	60·4	121·9	7·5	14·9	8·6	17·2	10	547	556
11	5·97	16·5	69·7	139·4			10·1	20·3	11		639
12	6·28	18	78·8	157·7			11·8	23·5	12		725
13	6·60	19·5	88·5	177·1			13·6	27·1	13		817
14	6·92	21	98·7	197·4			15·5	30·9	14		914
15	7·24	22·5	109·3	218·7			17·6	35·1	15		1015
16	7·55	24	120·3	240·7			19·8	39·5	16		1121
17	7·87	25·5	131·9	263·9			22·0	44·0	17		1232
18	8·19	27	144·0	288·1			24·5	48·9	18		1348
19	8·50	28·5	156·5	312·9			26·9	53·9	19		1467
20	8·82	30	169·5	339·0			29·6	59·3	20		1593

Note.—To extend this table to foundations of increased breadth, multiply the numbers in column 4 of next Table (B). by the increase of breadth, and add the product to column 4 of this table; this gives the *area* of the required foundation, *e. g.* the area of a bed of concrete under wing of a 10 feet high drain of increased breadth (q) = 1 foot ∴ $A' + q\,L = 604 + (1 + 21{\cdot}2) = 625$, which by depth of bed gives the content.

TABLE B.—PART I.

DRAINS.

SUPERSTRUCTURE OF WING WALLS.

Formation Heights.	Body of Wings.						Pyramids at Shoulders.		Formation Heights.	Pyramids & Bodies combined.	
	Breadths of base parallel.	Lengths.		Area.		Cubic feet in one.	Slab Drains.	Culverts.		Slab Drains.	Culverts.
	To axis of road.	Perpendicular.	Parallel to axis of wing.	Shoulder end parallel to axis of road.	True mean prismoidal.		Cubic feet in one.	Cubic feet in one.		Cubic feet in four.	
H	B	l	L	A	A_p	C	$\frac{A''H}{3}$	$\frac{A''H}{3}$	H	$4\left(C+\frac{A''H}{3}\right)$	
2	2·42	3	4·2	4·2	1·98	6	·4	·6	2	25	26
3	2·73	4·5	6·4	6·8	3·13	14	1·0	1·4	3	60	62
4	3·04	6	8·5	9·6	4·39	26	2·0	2·7	4	112	115
5	3·36	7·5	10·6	12·8	5·75	43	3·6	4·7	5	187	191
6	3·67	9	12·7	16·3	7·22	65	5·9	7·4	6	284	289
7	3·99	10·5	14·8	20·2	8·79	93	9·1	11·0	7	406	414
8	4·31	12	17·0	24·3	10·47	126	13·3	15·7	8	557	567
9	4·62	13·5	19·1	28·8	12·26	166	18·4	21·4	9	738	750
10	4·94	15	21·2	33·6	14·15	212	24·8	28·6	10	948	963
11	5·26	16·5	23·3	38·7	16·15	267		37·1	11		1214
12	5·57	18	25·5	44·0	18·25	329		47·0	12		1502
13	5·89	19·5	27·6	49·8	20·46	399		58·7	13		1831
14	6·21	21	29·7	55·9	22·79	479		72·3	14		2203
15	6·53	22·5	31·8	62·3	25·20	567		87·8	15		2619
16	6·85	24	33·9	69·0	27·73	666		105·3	16		3083
17	7·16	25·5	36·1	75·9	30·36	774		124·7	17		3595
18	7·48	27	38·2	83·3	33·10	894		146·7	18		4163
19	7·79	28·5	40·3	90·8	35·95	1025		170·6	19		4780
20	8·11	30	42·4	98·8	38·90	1167		197·6	20		5458

Note.—The content of a wing of other splay ϕ than 45° = C = $\frac{\text{tabular content} \times \sec \phi}{1{\cdot}414}$ and of one of other ratio of slope of bank than 1½ to 1 = Tabular content × other ratio ÷ 1·5.

Areas for intermediate heights may be got by interpolation.

TABLE C.

LENGTHS OF COPING OF WING-WALLS OF DRAINS.

Formation Heights.	One. λ *	Four. 4 λ
3	7·0	28·1
4	9·4	37·4
5	11·7	46·8
6	14·0	56·2
7	16·4	65·6
8	18·8	75·1
9	21·0	84·1
10	23·5	93·8
11	25·8	103·1
12	28·1	112·4
13	30·5	121·9
14	32·8	131·3
15	35·2	140·7
16	37·5	150·0
17	39·9	159·4
18	42·2	168·8
19	44·6	178·2
20	46·9	187·6

TABLE D.

CONTENTS OF COUNTERFORTS.

Height of Wall.	Foundations of one.†	Superstructure of one.
10	Part I. = 30 cubic feet. Part II. = 45 "	150
11		165
12		180
13		195
14		210
15		225
16		240
17		255
18		270
19		285
20		300
21		315
22		330
23		345
24		360
25		375
26		390
27		405
28		420
29		435
30		450
31		465
32		480
33		495
34		510
35		525
36		540
37		555
38		570
39		585
40		600

TABLE E.

SEGMENTAL QUANTITIES.

CHORD ÷ HEIGHT $c \div h$	Centre angle. v.	Radius. $R = K_0\, c$.	Circular arc. $b = K_1\, c$.	Segmental area. $a = K_2\, c_2$.	Chord. $c = K_2\, R$.
		K_0	K_1	K_2	K_3
7·4565	60°	1·000	1·0470	·09106	1·00
6·	73° 44′	·8353	1·0324	·1135	1·20
5·	87° 12′	·725	1·1034	·13755	1·379
4·	106° 14′	·625	1·1584	·17457	1·6
3·	134° 46′	·5417	1·2741	·24096	1·846

Miscellaneous Rules in Segmental Arches.

Length of a skew back of segmental arch $= \frac{d\,C}{2\,R}$.

Height of do. $= \frac{d\,(R-h)}{R}$

Thickness of arch-stone on extrados $= t\left(1 + \frac{d}{R}\right)$.

Where :—c, h, R, as in above table.

d = depth of arching.

t = thickness of arch-stone on intrados.

TABLE to convert Inches into the equivalent Decimals of a foot, and *vice versâ*.

Inches.	Feet.	Inches.	Feet.
$\frac{1}{16}$	·0052	5	·41663
$\frac{1}{8}$	·0104	$5\frac{1}{2}$	·458
$\frac{1}{4}$	·0208	6	·5
$\frac{3}{8}$	·0312	$6\frac{1}{2}$	·5416
$\frac{1}{2}$	·0416	7	·5833
$\frac{5}{8}$	·0521	$7\frac{1}{2}$	·6250
$\frac{3}{4}$	·0625	8	·6666
$\frac{7}{8}$	·0729	$8\frac{1}{2}$	·7083
1	·0833	9	·75
$1\frac{1}{2}$	·1249	$9\frac{1}{2}$	·7916
2	·1666	10	·8333
$2\frac{1}{2}$	·2082	$10\frac{1}{2}$	·8750
3	·25	11	·9166
$3\frac{1}{2}$	·2916	$11\frac{1}{2}$	·9583
4	·3333	12	1·0000
$4\frac{1}{2}$	·3750		

* $\lambda = \sqrt{L^2 \times H^2} = 2{\cdot}345\ H$

† Area of Foundations = 30 for two.

Plate XXXVI.

Fig. 1.

Fig. 2.

Fig. 3.

Drawing of a Pier with Plinth

The dotted lines shew the arrangement of Pier without Plinth.

Fig. 4.

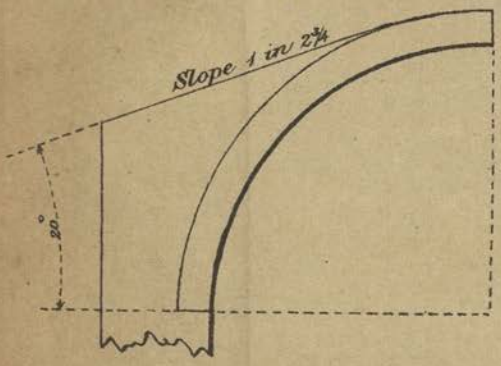


Fig. 10.

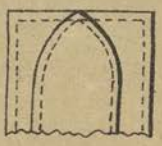


Fig. 5.

Fig. 6.

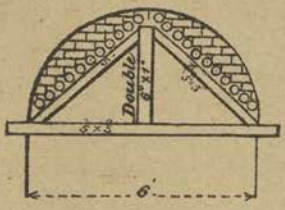


Fig. 7.

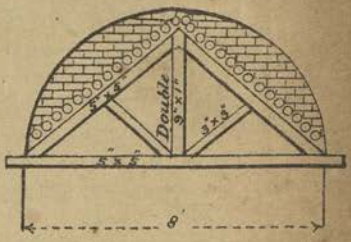


Fig. 8.

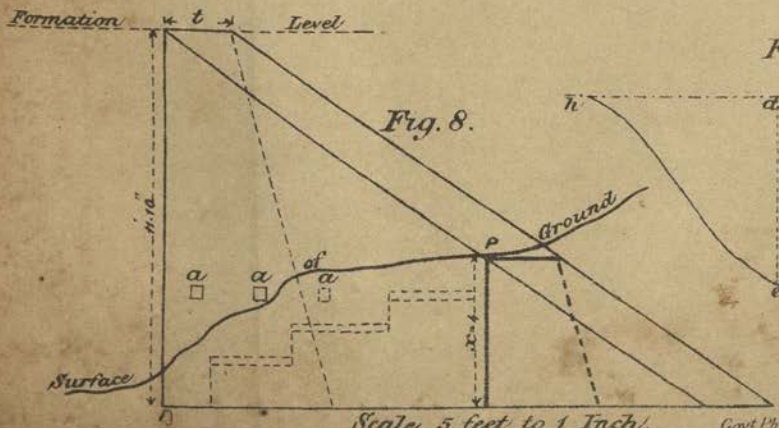
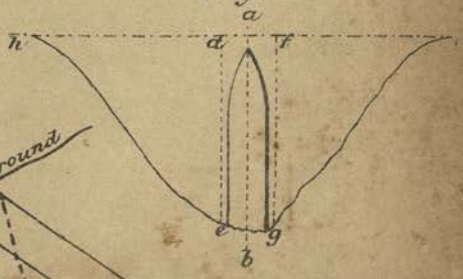


Fig. 9.



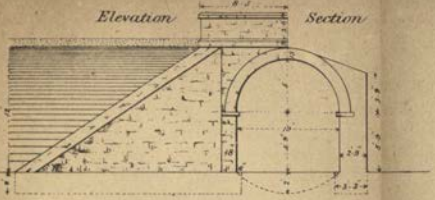
Govt Photozinco. Office, Poona. 1868

10 Feet Culvert.

Single Drain.

Semicircular

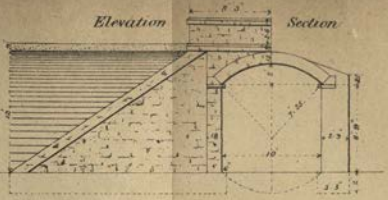
Elevation



Section

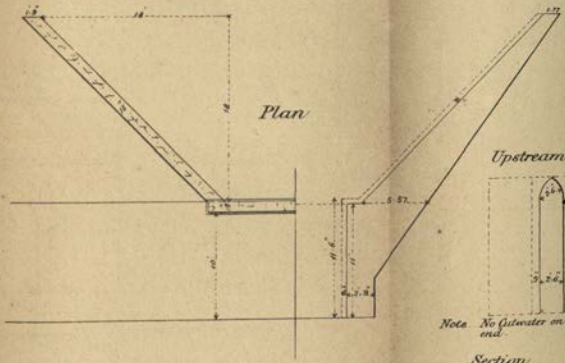
Segmental

Elevation

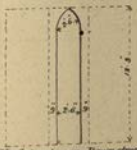


Section

Plan



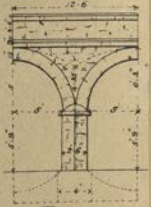
Upstream end



Note. No Cutwater on Downstream end.

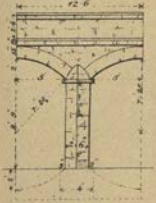
Additional Span

Semicircular

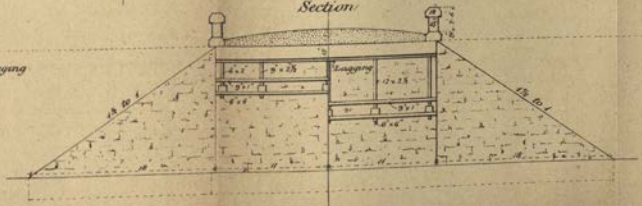


Upstream

Segmental

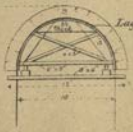


Section



Centers

Centers



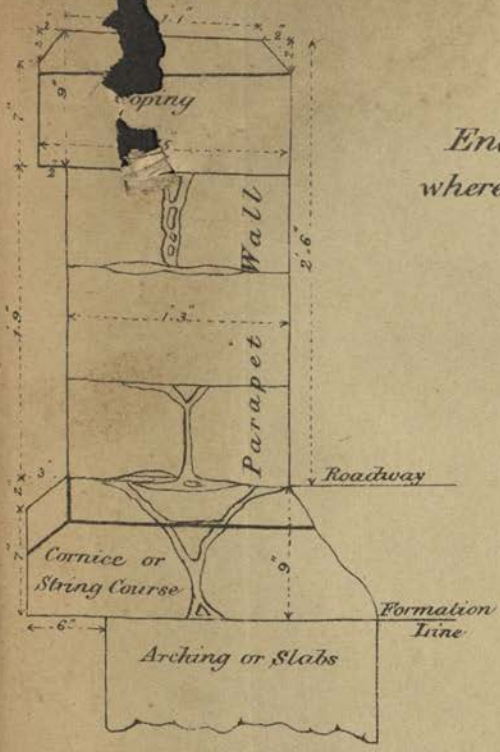
Scale. 10 feet to an Inch.

Govt Photozinco Office, Poona, 1867.

Details.

Enlarged Section of Parapets where required.

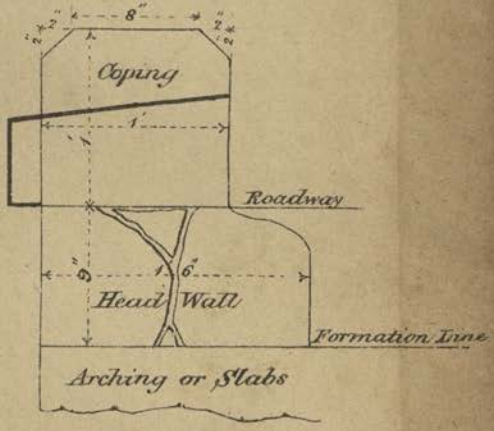
Fig. 18.



Area of Coping = 1·06 S.F.
Area of Parapet = 2·19 S.F.

Enlarged Section of Coping where Parapets are not required

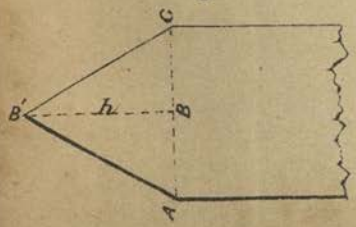
Fig. 19.



Area of Coping = 1 S.F.
According to Black lines = ·63 S.F.

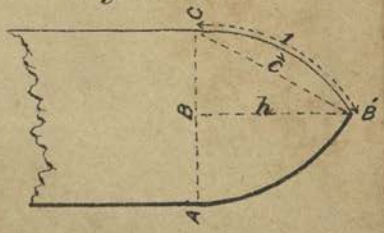
Note. Where Trapean rocks are scarce, and those of a slaty character abundant, Copings and Cornices as shewn by Black lines, may be used where Area of Coping = 0·813, Area of Parapet = 2·5.

Fig. 20.



Plan of Cutwaters

Fig. 21.



Scale, 1 foot to 1 Inch.

Govt. Photozinco Office, Poona, 1887.

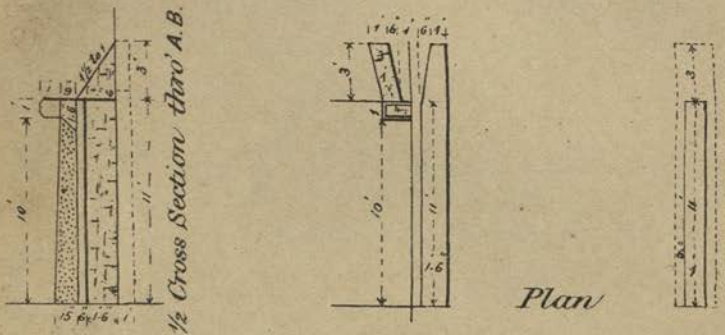
Slab Drain

Plate XXXIX.

Single Drain

Additional Drain

Elevation



½ Cross Section thro' A.B.

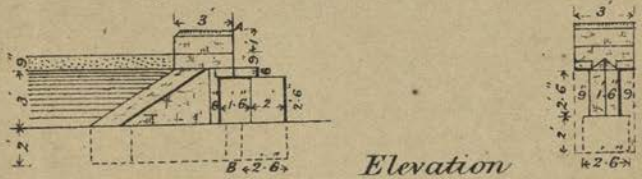
Plan

Scale, 10 feet to an Inch

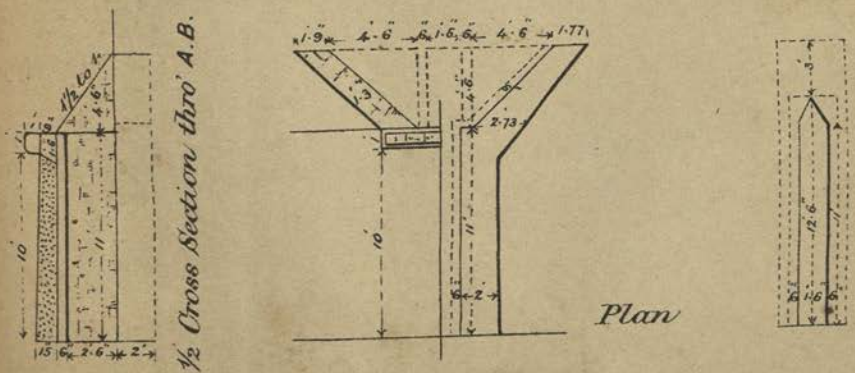
1½ Feet Slab Drain

Single Drain

Additional Drain



Elevation



½ Cross Section thro' A.B.

Plan

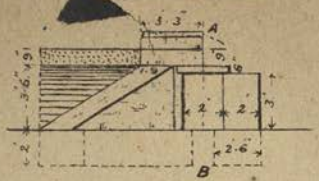
Govt Photozinco Office, Poona, 1887

Scale, 10 feet to an Inch.

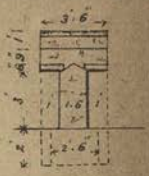
Plate XL.

2 Feet Slab Drain

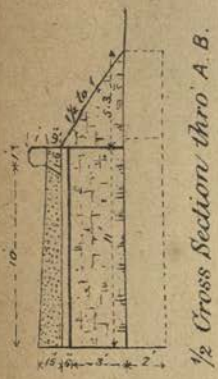
Single Drain



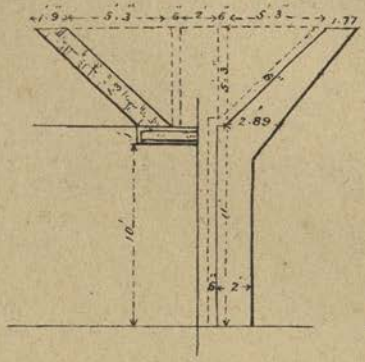
Additional Span



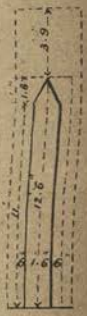
Elevation



½ Cross Section thro' A. B.



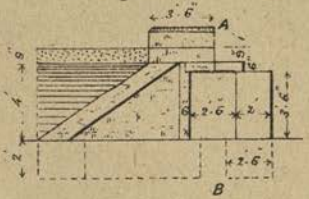
Plan



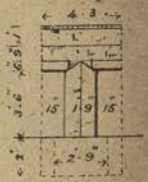
Scale, 10 feet to an Inch.

2½ Feet Slab Drain

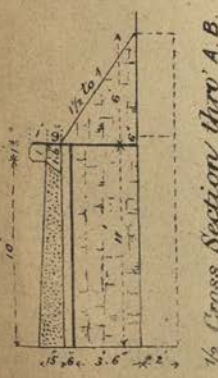
Single Drain.



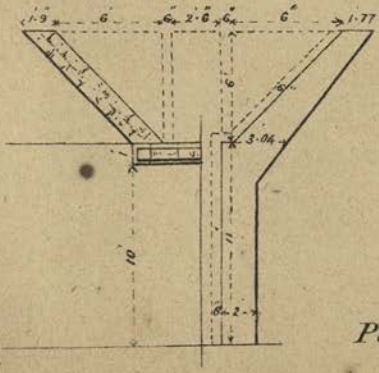
Additional Span



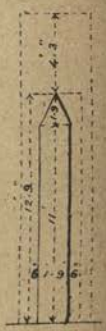
Elevation



½ Cross Section thro' A. B.



Plan

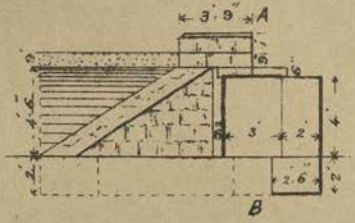


Govt Photozinco Office, Poona 1887

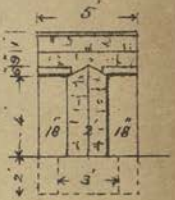
Scale, 10 feet to an Inch.

3 Feet Slab Drain

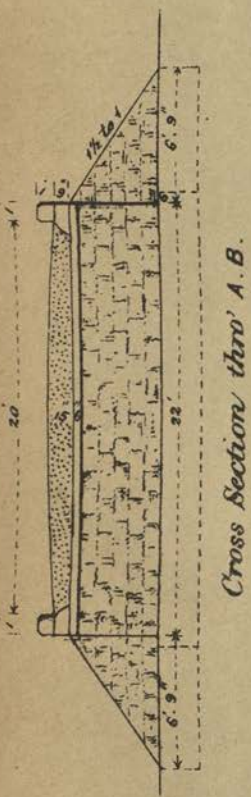
Single Drain



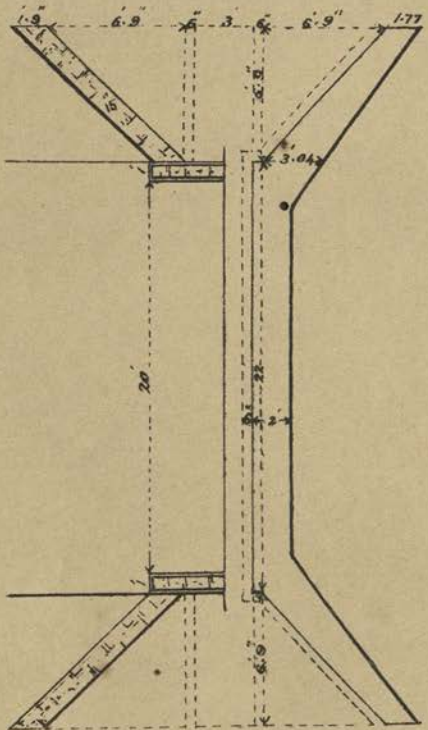
Additional Span



Elevations.



Cross Section thro' A.B.



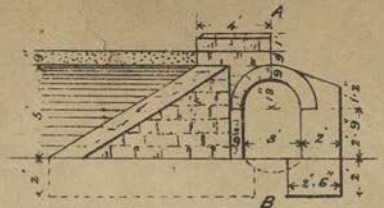
Plan

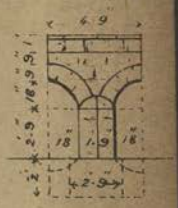
Govt Photozinco Office, Poona, 1887. Scale, 10 feet to an Inch.

Feet Culvert. Plate XLII

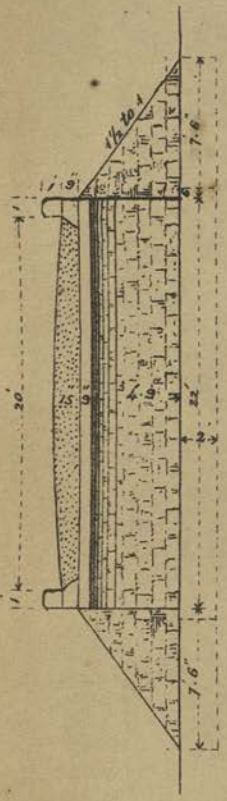
Single Drain

Additional Spa

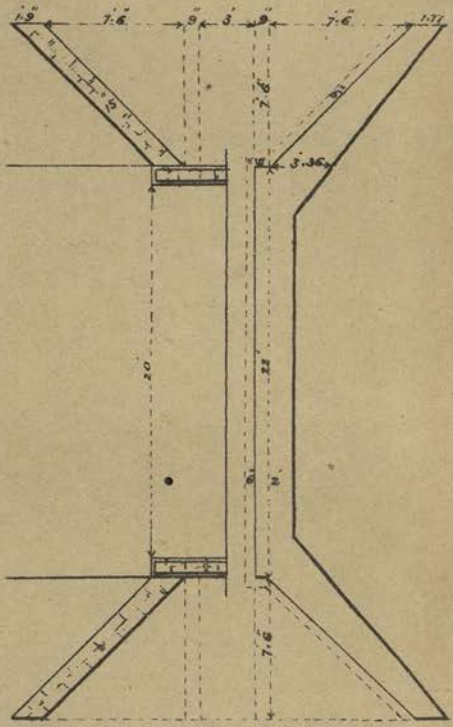




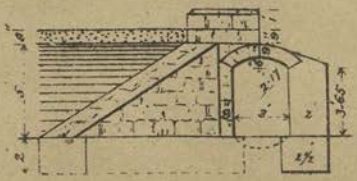
Semicircular Elevations.



Cross Section thro' A.B.



Plan



Segmental Elevations

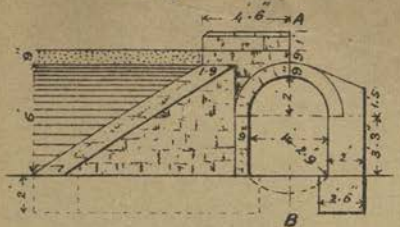
Scale, 10 feet to an Inch.

Gov't Photozinco Office, Roma, 1887

4 Feet Culvert

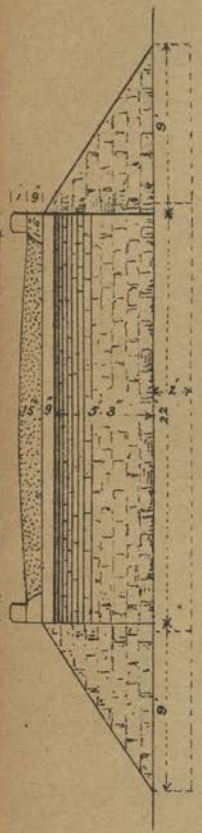
Plate XLIII.

Single Drain

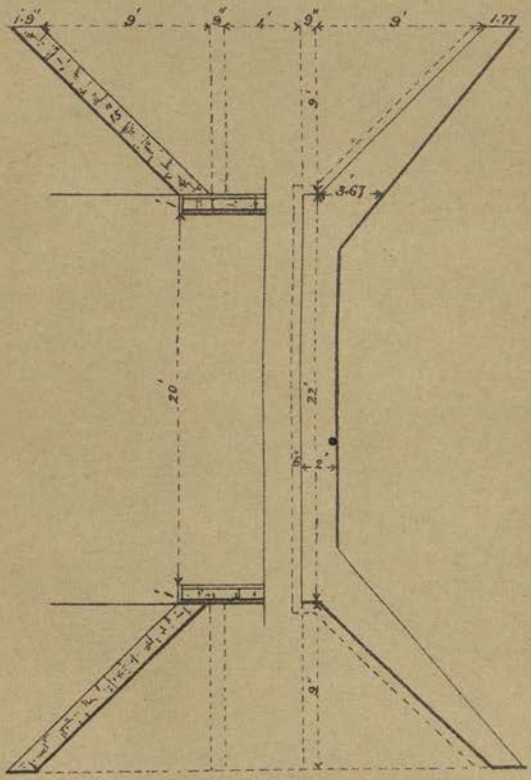


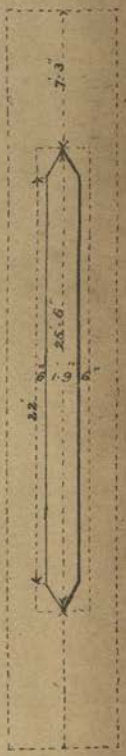
Additional Span

Semicircular Elevations.



Cross Section thro' A. B.





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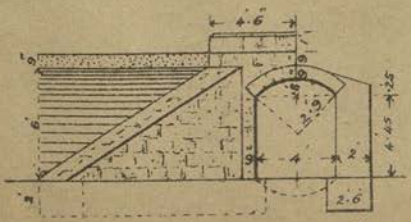
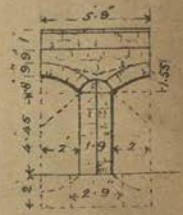




Segmental Elevations.

Scale, 10 feet to an Inch.

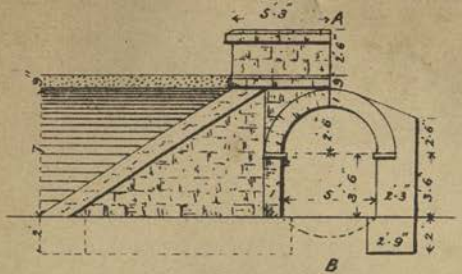
Govt Photozinco. Office, Poona. 1887.

Plate XLIV.

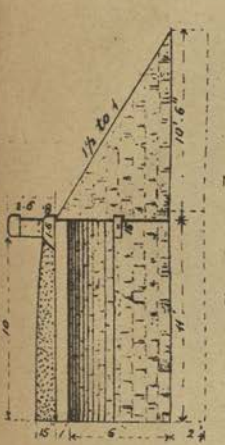
5 Feet Culvert

Single Drain

Additional Span



Semicircular Elevations



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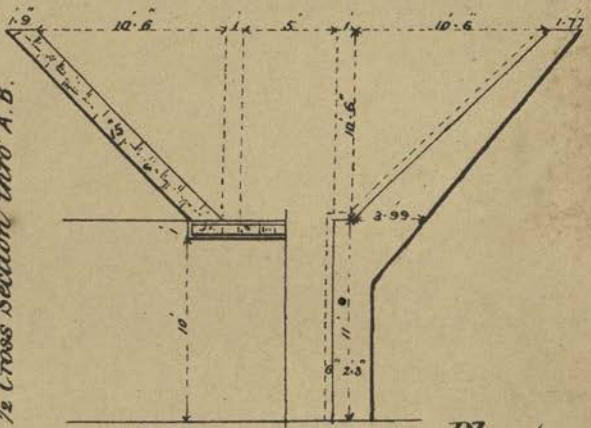
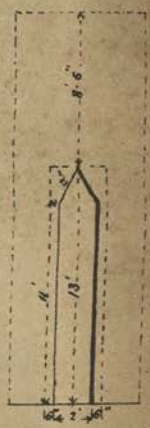
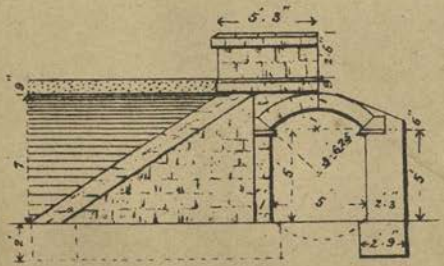


Plan





Segmental Elevations.

Scale, 10 feet to an Inch.

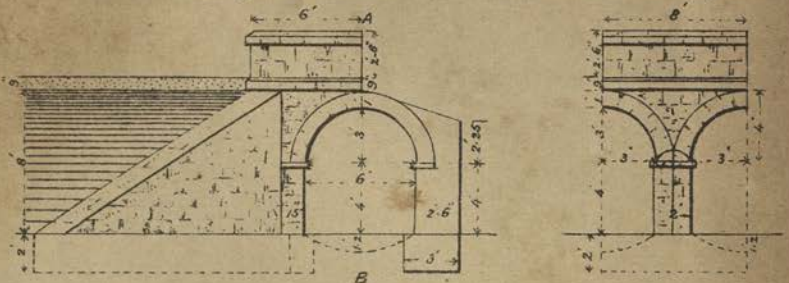
Govt. Photozinco. Office Poona. 1887

Plate XLV.

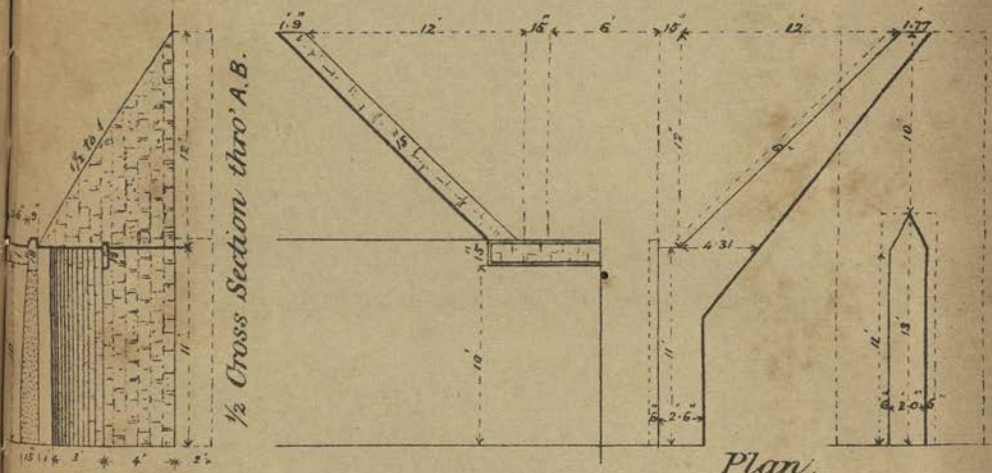
6 Feet Culvert.

Single Drain

Additional Span

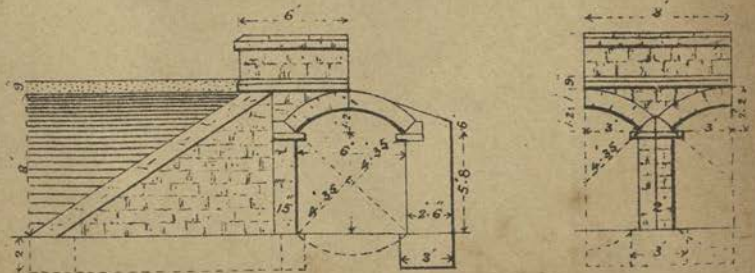


Semicircular Elevations



½ Cross Section thro' A.B.

Plan.



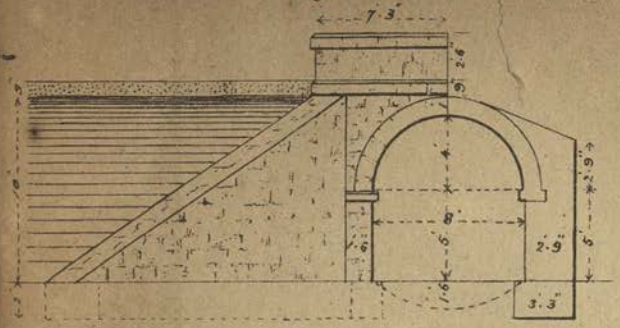
Segmental Elevations.

Scale, 10 feet to an Inch

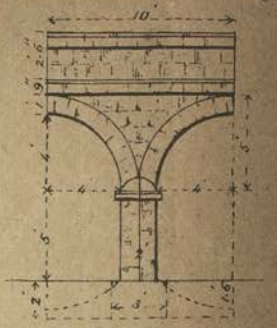
Govt Photozinco Office Poona 1887

Plate XLVI.

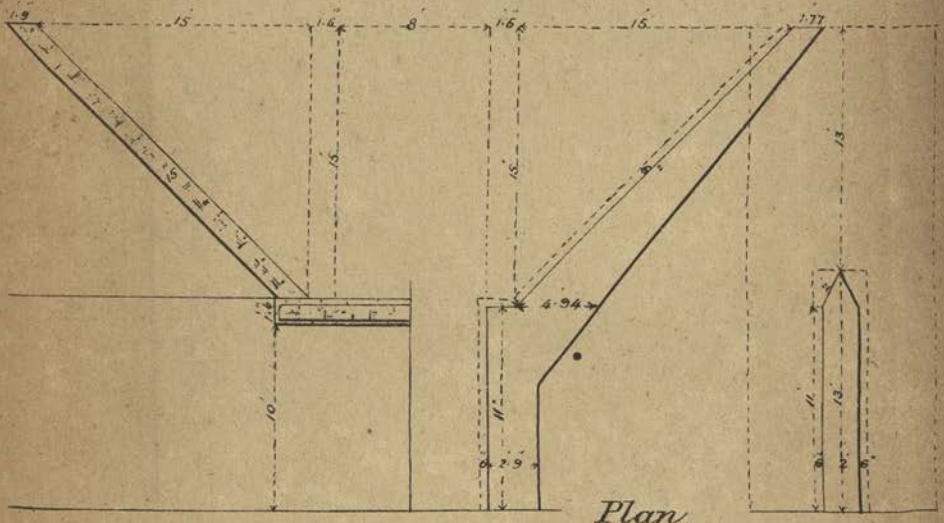
Single Drain



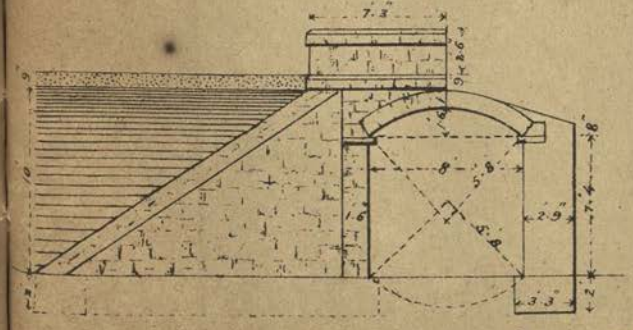
Additional Span.

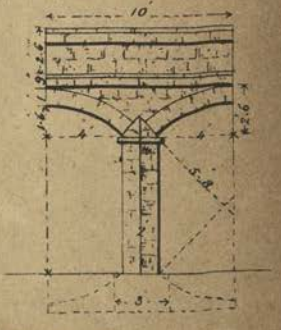


Semicircular Elevations



Plan





Segmental Elevations

Scale. 10 feet to an Inch

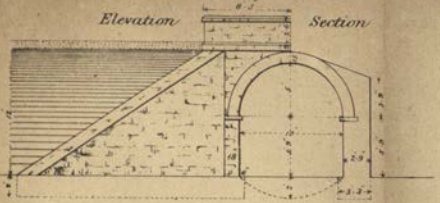
Govt Photozinco. Office, Poona. 1887

10 Feet Culvert.

Single Drain.

Semicircular

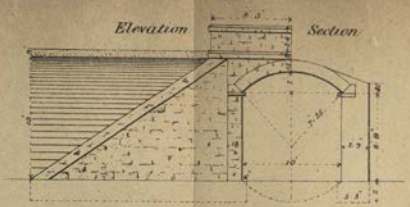
Elevation



Section

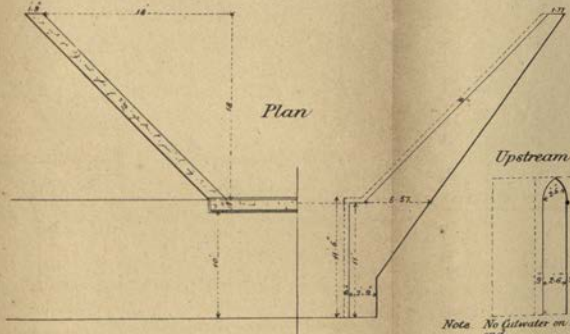
Segmental

Elevation

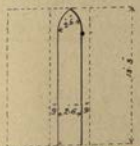


Section

Plan



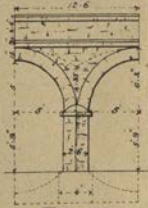
Upstream end



Note. No Cutwater on Downstream end.

Additional Span

Semicircular



Upstream

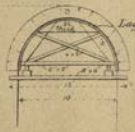
Segmental

Centers

Lagging

Section

Centers



Lagging

Scale, 10 feet to an Inch.

Govt Photozinco Office, Poona, 1887

CUTWATERS may be formed by describing an equilateral triangle with plane sides on the ends of the pier, and this is found to be a convenient form, as in *Fig.* 20 ; or by a similar triangle with curved sides as in *Fig.* 21, which is formed by describing two intersecting arcs, with the end corners of the pier as centre, and the breadth of the pier as radius.

The following is a Table of the values of the various areas and lines in such cut-waters advancing by 3 inches in breadth of pier.

TABLE F.

B	a_t ·433 B²	a_s ·091 B²	A ·615 B²	h ·866 B	l 1·047 B	B	a_t ·433 B²	a_s ·091 B²	A ·615 B²	h ·866 B	l 1·047 B
1·5	·97	·20	1·38	1·299	1·57	6·5	18·29	3·84	25·98	5·629	6·81
1·75	1·32	·27	1·89	1·515	1·83	6·75	19·72	4·14	28·01	5·765	7·07
2	1·73	·36	2·46	1·732	2·09	7	21·21	4·46	30·13	6·062	7·33
2·25	2·19	·46	3·11	1·948	2·36	7·25	22·75	4·78	32·32	6·278	7·59
2·5	2·70	·56	3·84	2·165	2·62	7·5	24·35	5·11	34·59	6·495	7·86
2·75	3·27	·68	4·64	2·380	2·88	7·75	26·00	5·46	36·93	6·711	8·11
3	3·89	·82	5·54	2·599	3·14	8	27·71	5·82	39·37	6·928	8·38
3·25	4·57	·96	6·49	2·814	3·40	8·25	29·46	6·19	41·85	7·188	8·64
3·5	5·30	1·11	7·53	3·031	3·66	8·5	31·28	6·57	44·43	7·361	8·90
3·75	6·08	1·27	8·65	3·247	3·96	8·75	33·15	6·96	47·08	7·577	9·16
4	6·92	1·46	9·84	3·466	4·18	9	35·07	7·37	49·81	7·794	9·42
4·25	7·81	1·64	11·10	3·685	4·44	9·25	37·04	7·78	52·61	8 010	9 68
4·5	8·76	1·84	12·45	3·897	4·71	9·5	39·07	8·22	55·50	8·227	9·95
4·75	9·76	2·05	13·87	4·113	4·98	9·75	41·16	8·65	58·46	8·443	10·20
5	10·82	2·27	15·38	4·333	5·24	10	43·30	9·10	61·50	8·666	10·47
5·25	11·93	2·50	16·94	4·546	5·49	10·5	47·73	10·03	67·80	9·693	10·99
5·5	13·09	2·75	18·60	4·863	5·76	11	52·39	11·01	74·41	9·526	11·52
5·75	14·31	3·00	19·33	4·979	6·02	11·5	57·26	12·03	81·33	9·959	12·04
6·	15·58	3·27	22·14	5·196	6·28	12	62·35	13·10	88·56	10·39	12·56
6·25	16·91	3·55	24·02	5·412	6·54						

B = breadth of pier A′ C′ = C = A B′.

a_t = area of triangle A′ B′ C′ with plane sides.

a_s = area of one side segment.

A = area of triangle ABC with curved sides = $a_t + 2a_s$.

h = length of cut-water.

l = length of one curved face of cut-water.

v = versed sine of side segments = ·134 B.

PART II.—BRIDGES.

The designs are those of simple Bridges of 15, 20, 25, and 30 feet span, such as are suited to ordinary streams crossed by Indian roads. In each drawing is shown alternative designs for wing walls.

1*st*. When *splayed wings* retain the banks.

2*nd*. When the head-walls are "*returned*" back into the bank.* The former is useful in case of rivers with low banks and high approaches; the latter for high abrupt banks with low approaches.

In the former the filling is considered to have *side* slopes of 1½ to 1; but in the latter the slope of the *banks* must not exceed 1 to 1, whether they do not do so naturally; or whether they be made not to do so by pitching; because it appears from the tables that when the ratio of slopes of 1 to 1 is exceeded it will be much more economical to use splayed wings than returned walls.

2. Each drawing also shows examples of both segmental and semicircular arches. The segments have rises, or versed sines, of one-fifth the span. A comparison is given of the relative quantities, in equally high Bridges, of both descriptions of arching, and the differences entered at the foot of the table of quantities.

3. *Foundations* are shown as a single block (except in piers), and of a depth of 3 feet; but the material may be disposed differently, as shown in *Figs.* 9 and 10, *Plate* XLVIII, Part II.; or any further depth may be provided for after the method shown in page 354, Art. 40, Part I.

4. The *contents* of *wings* are calculated by the Prismoidal Formula, and their dimensions and arrangements are shown in *Plate* XLVIII., Part II.

Their section is as in *Fig.* 5. On the square, that is at right angles to their longitudinal axis, their breadth at top is 1½ feet, their face batter is 1 in 12, and that of the back 1 in 6, built in steps. The axis, and therefore the line of the top edge, splays at an angle of 45° (1 to 1).

The wing proper is connected with the abutments and returns, as shown in *Figs.* 2, 4, and 8, by a pyramid on a triangular base of the same height as the wall, and a wedge on a rectangular base of a height less by 9·8 feet. The batter of the back of the pyramid is the same as that of the back of the wing, and that of the wedge is ·256 the height, or 1 in 2·95 (nearly 1 in 3); *see* Appendix, page 406.

The depth of the foundations of the wings is 3 feet, and the projection of the footings is 9 inches, but the arrangement of the material may be altered, as in *Figs.* 9 and 10, if an extension of the area of base be required.

* The quantities for this design are shown by *sloped* figures in Table I.

The stability of these walls is nearly that of a vertical faced rectangular wall of a base two-ninths of the height.

The height of the wing is the same as that of the formation, which, in the case of Bridges, is 6 inches over the level of the extrados of the arch ring.

5. The same methods of obtaining the contents of wing walls cut off short, or stepped up the banks, shown in the case of Drains (Part I. Arts. 22, 26, and 27) may be adopted here, *vide Fig.* 3, *Plate* XLVIII., Part II., and example, Appendix, page 407.

The design of the wings may be somewhat altered, without any sensible error in the quantities, provided the area of section, and breadth of base on the square, remains the same.

6. The average wings may be used for Bridges without pilasters, by letting the line CK coincide with the back of the abutment, in which case the rectangular part of the shoulder (as given in Appendix, page 407, Table G.,) should be deducted from the contents of the masonry in both foundations and superstructure, and the wing would take the position shown in *Fig.* 4*a*, *Plate* XLVIII., Part II.

7. When the splay of the wing is altered the same Rules as in Part I. hold good; and it is to be remembered that to keep the result as closely accurate as practicable the angle $\phi^\circ + \beta^\circ$ must be retained constant, *i. e.* equal 49° 30′.

8. In construction, weep holes should be introduced at every square yard up to one-half the height; and every care should be taken to have the back well drained, and the filling consolidated.

The back batter should be formed by 6 inch off-sets.

9. *Returned wings*, or retaining walls used in the 2nd alternative designs, are of a sectional area equal that of the splayed wings on the square, *vide Fig.* 7, and have a stability equal that of a vertical rectangular wall of a base $\frac{6}{11}$ the height.

Their length, measured from the back of the abutment, is equal to the height of formation.

They are drawn to the full height; but, as in the case of wings, they should be stepped up the banks when the material of the ground will admit of such being done with safety; great care being taken that the foundation is of uniform compressibility; or, that if not, extra footings be given to the steps as they rise.

The precautions given regarding the construction of wing walls should be equally attended to in these walls; and when their heights equal, or exceed, 25 feet there should be a counterfort at the back, at every 12 feet, if the filling behind is treacherous.

10. *Abutments* are about one-fourth of the span in thickness. This is a little over what is necessary for low bridges, so that, in practice, by the use of counterforts the masonry in this part may possibly be somewhat diminished. In the Tables, counterforts, rising to level of springing of segmental arches, are provided to those Bridges whose height of

formation equals, or exceeds, five times the thickness of abutment. For quantities *See* Table D., Appendix, Part I., page 382.

11. *Parapets* to be as shown in *Fig.* 11, *Plate* XLVIII., Part II., and in case of necessity the modifications of the string course and coping there shown may be adopted.

The plinth, or projection on the inner face, serves to protect the coping from injury, reduces its breadth and therefore, its cost.

The areas marked on the drawing show the C. F. in each part per foot running.

12. *Imposts, Cornices,* and *Copings* are of cut stone. The impost course is only carried round the ends of the piers and abutments for sake of appearance, and the *rate* for this work is only to include the extra cost of the superior stones and dressing of them.

13. The Cornice *rate* is to include the rubble masonry backing behind the stones composing the cornice, and amounting to about 1 cubic foot per running foot of cornice; it will of course also include the cost of the stones and dressing; in this point the mode of calculating the cornice rate differs from that in Part I.; because, there the introduction of cornices is not always certain, here it is so.

The Coping *rate* will include the stones and their dressing.

14. The "coping on wings" (sometimes called "paving") is composed of slab-stones, set projecting 1 inch on the face: their upper surfaces to be dressed true; and to coincide with the plane of the side slopes of the approaches. Their side joints should be parallel to the face of the bridge, although for economy's sake they are sometimes laid perpendicular to the face of the wing.

The length of this coping, is $\lambda = \sqrt{(H-h)^2 + L^2}$; and $L = r \sec \phi$; wherefore, its length in these plans $= 2{\cdot}345\ (H - 3)$, from which formula the lengths in Tables have been calculated.

For other splays; $\lambda' = \frac{\lambda \sec \phi'}{1{\cdot}414}$, &c.

15. Centres are designed of "framed" timbers, as shown in the drawings.* They consist of braced ribs placed at a distance of about 5 feet apart. The curved part of the rib is formed of double planking from 2 to 3 inches thick, bolted together; and this rib is tied at the foot, and somewhat braced diagonally. On the curve of the planking rest the laggings, which are 2 inches thick, and vary from 3 to 5 inches broad; only one out of three need be nailed to the rib; their edges need not be in any way smoothed off. The ribs are lowered by sand boxes, or cylinders; and over and under these are longitudinal 1 inch planks which tie the feet of the ribs and the tops of the lower props axially together. The props or supporting posts rest on the abutment footings, if not too high; otherwise on corbels left in the walls; or on temporary piers of rubble masonry.

* The centrings alluded to have not been shown in the plans as the scale to which they are drawn is too small to admit of this being done. The quantities of wood and iron work in each centring are given in the Tables to furnish an approximate idea as to the cost of ordinary framed centrings for each such span.

In the centres for the semicircular arches, each frame, or principal, is divided into two parts—the lower, which is fixed, and the upper, which is capable of being lowered by the sand boxes; this is also so designed that it can be used for segmental arching. For example, the upper truss of a 20 ft. arch will suit a 15 ft. segment, with a rise of about 3½ feet; that of a 30 ft. arch, one of a 25 ft. segment, rising about 6 feet 9 inches; and so on. By laying a coat of mud and stone over the laggings of these framed centres they can be made to answer for elliptical arches; or segments of a different rise from those of the plans.

Temporary ties of rafters are to be introduced when necessary; their ends are shown in the elevations, but they are not shown in the transverse sections, to avoid confusing the drawing.

When the height makes it practicable, it will add to the stiffness of the ribs if they are supported in the middle by temporary props, which can be removed when the arch is keyed. The ribs are however strong enough without this; but it would prevent any straining of the timber if done, and there are always stray rafters about the work which could be so used.

The ribs should be placed about 5½ feet apart; but if need be the distance from centre to centre may be increased to 6 feet, beyond which the laggings will not bear the weight of the arch stones without greater deflection than could be allowed in practice. It will be remembered that this allows a bridge of 25 or 26 feet long to be built without increasing the number of ribs shown in these designs.

16. The number of centres required for Bridges of more spans than one is as follows:—

Two are required for 2 and 3 arches.
Three „ „ „ 4 and 5 „
Four „ „ „ 6 and 7 „ , and so on,

or let n = number of arches in a bridge, then the next greatest whole number to that represented by $\frac{n+1}{2}$ will be the number of centres required; this gives the number with *one removal* only; but, if the time required for construction is of no consequence, any number, over 2, can be made to suffice, and the number will depend on the expedition with which the arches are to be built.

17. The cost of erecting and removing centres should form an item in the estimate, and in it should be included the cost of carriage, if any. The number of removals, &c., will of course equal the number of spans.

18. The quantities of centres have been so taken out that the extra amounts for longer bridges, or the reverse, can be readily ascertained, *i. e.* the content of rib is given, and also the quantities in one foot running of Laggings, Planks and Ties. (*See* notes to Tables I. and II.)

The *Breadth of Bridge* ÷ 5·5 plus one will give, in whole numbers, the number of ribs; and this multiplied by the content of one will give

the quantities, due to the ribs; and in the same manner iron work, and sand boxes.

Also, the quantities in one foot of Laggings, &c., multiplied by the breadth of Bridge, will give the quantities due to these items.

19. *Explanation and use of Tables* in Part II.

Table I., is used to find the quantities of work in any given Bridge, as shown in page 356, Art. 44, Part I.

Table II., is used as shown in Arts. 49, 50, page 360, Part I.

20. Example of the use of Table I.

SUNGRESSYKOP BRIDGE.

Five arches of 25 feet span—segmental. Formation height 17 feet; 20 feet road.

(1). *Design with splayed wings.**

Quantities in one span.	Additional spans. No.	Additional spans. Quantities in one.	Total in Bridge.	Description of Work.	Amount	Total.
					Rs.	Rs.
3099 + (4 × 866)			6563	c. ft. Excavation of foundation, @ Rs. 8 per 100.	197	
3099 + (4 × 670)			5779	,, Filling in do. (uncoursed rubble) ,, 25 ,,	1,445	
8400 + (4 × 1554)			14616	,, Superstructure (coursed rubble) ,, 30 ,,	4,384	
987 + (4 × 987)			4935	,, Arching, ,, 50 ,,	2,467	
16 + (4 × 22)			104	r. ft. Impost, ,, 1 r. ft.	104	
86 + (4 × 57)			314	,, Parapets, ,, 1 ,,	314	
87 + (4 × 57)			315	,, Cornice, ,, 1-8 ,,	473	
,, + ,, ,,			315	,, Coping on parapets, ,, 2 ,,	630	
131 + 0			131	,, ,, on wings, ,, 0-12 ,,	98	
4 + 0			4	No. Newal caps, ,, 4 each.	16	
0 + (4 × 2)			8	,, Starling caps, ,, 5 ,,	40	
			3	,, Centres (*see* Abstract of), ,, 567 ,,	1,701	
			5	,, Removals of do., ,, 25 ,,	125	11,993
				Add contingencies at 5 per cent., ...	..	600
				Grand Total, ..	..	12,593

Abstract of Centre :—

258 c. ft. Wood work, @ Rs. 4 per 100,† ...	1,032	
131 lbs. Iron work, ,, 0-4 ,, lbs. ...	52	
10 No. Sand boxes, ,, 5 each, ...	50	
	——	1,134

Deduct :—

½ value of centre on completion of work, ...		567
Total ...		567

* Had straight returned wings been adopted instead of splayed wings, the sloping figures under column "Returned walls" would have been used.

† Includes wastage.

21. If it were necessary to carry the foundations to a greater depth than shown in the plans, say to 6 feet (or double the average depth), the quantities in the above would be—

$6563 \times 2^a = 13126$ c. ft. excavation of foundations.
$5779 + (6563 \times 2^a) = 18905$ c. ft. filling in of ditto.

22. Example of use of Table II.

If the breadth of road had been 25 instead of 20 feet, an increase of 5 feet to the length of the bridge would have been necessary; and each item of the work would have been increased by 5 times the quantities in one foot of the length of bridge in Table II., Part II. Example :—

$3099 + 210^c + \{4\,(866 + 131{\cdot}5^d)\} = 7299$ c. ft. excavation of foundations.
Ditto, $\{4\,(670 + 106{\cdot}5)\} = 6415$ c. ft. filling in of ditto.
$8400 + 774{\cdot}5 + \{4\,(1554 + 258{\cdot}5)\} = 16425$ c. ft. superstructure.
$987 + 214{\cdot}5 + \{4\,(987 + 214{\cdot}5)\} = 6008$ c. ft. arching.

Impost, cornice, parapets, coping, newals, starlings as before.

Three centres as before, but according to following Abstract.

ABSTRACT OF CENTRE (ONE EXTRA RIB REQUIRED).

$258 + \frac{149}{5} + \frac{109 \times 5}{23}$	= 312 c. ft. Wood work,	@ Rs. 4 per 100,	=	1248
131 + 25·5	= 156 lbs. Iron work,	,, 0·4 per lb.	=	62
10 + 2	= 12 No. Sand boxes	,, 5 each,	=	60
		Total (*e*),	...	$\frac{1370}{2} = 685$

23. For skew Bridges, the skew length may be taken as the length of the bridge for a closely approximate estimate of the quantities.

The skew length = length on square × secant angle of skew.

The angle of skew being that which is less than 90°.

SPECIFICATION OF WORK.—BRIDGES.

The work to be as specified for each sort in the "General Specification" for work in the district.

Filling in of *Foundations* to be of "uncoursed rubble."

---

a, *b*, 2, because double the average plan depth.
c, $42 \times 5 = 210$.
d, $26{\cdot}3 \times 5 = 131{\cdot}5$.
e, Had we used $\frac{5}{23}$ cost we would have had it $123 + 567 = 690$.

Superstructure of "coursed rubble" with roughly dressed corner stones.

Arching to be of "*Hammered squared rubble,*" set in lime with cut *quoins* "pitch-faced."

Wings to be *paved* with 4 inch flat stones, projecting 1 inch.

Impost and *cornice* courses, as well as *Coping,* to be of *cut stone,* or superior "block-in-course."

Centres to be of teak, or eyne, framed; the arch stones will be laid directly on laggings.

The ribs will be tied at the feet by planking laid horizontally over the sand boxes, or wedges, and braced transversely with rafter-ties where necessary.

Sand boxes will be used in easing, or striking the centres. Iron cylinders will, if procurable, be used instead of wooden boxes. The sand must be very fine, such as might almost be used in an hour glass, and it must kept dry while under the centre, else it will not run freely when the doors are opened.

Laggings are 2 inch planking laid close; no plank to exceed 4 inches in breadth.

TABLE I. PART II.

QUANTITIES IN BRIDGES

ON

ROADS 20 FEET WIDE,

CALCULATED FOR

ALL FORMATION HEIGHTS.

LENGTH OF ABUTMENT, 23 FEET.

20 FEET

15 Feet

Formation Heights.	Bridge of Single Span.																
	Excavation, and Filling. Foundations, Cubic feet.		Superstructure, Cubic feet.		Arching, Cubic feet.	Impost, Running feet	Parapets, Running feet.		String course and Coping, Running feet.		Newal Caps, No.	Coping on Wings, Running feet.	Centres. Wood Work, Cubic feet. Ribs=53 Laggings=68.	Iron Work, lbs.	Sand Boxes, No.	Rafters, No.	Removals, No.
	1	2	3	3	4	5	6	6	7	8	9	10	1	2	3	4	5
Design with ☞	Wings.	Returned walls.	Wings.	Returned walls.	Wings or Returned Walls.		Wings.	Returned Walls.	Wings.	Returned Walls.	Wings.		Wings or				

Quantities for Seg

6	1246	*1098*	1286	*1133*				*70*		*71*		28					
7	1348	*1167*	1638	*1465*				*74*		*75*		37					
8	1455	*1242*	2015	*1831*				*78*		*79*		47					
9	1570	*1323*	2426	*2233*				*82*		*83*		56					
10	1693	*1410*	2867	*2673*				*86*		*87*		66					
11	1830	*1503*	3346	*3155*				*90*		*91*		75					
12	1974	*1602*	3870	*3683*				*94*		*95*		84					
*13	2125	*1707*	4431	*4258*				*98*		*99*		96					
14	2284	*1818*	5042	*4885*				*102*		*103*		103					
15	2448	*1935*	5701	*5565*				*106*		*107*		112					
16	2619	*2058*	6408	*6303*	502	16	58	*110*	59	*111*	4	122	†121	26	10	...	1
17	2798	*2187*	7151	*7100*				*114*		*115*		131					
18	2983	*2322*	7973	*7961*				*118*		*119*		141					
19	3233	*2463*	8841	*8886*				*122*		*123*		150					
‡20	3643	*2700*	10230	*10333*				*126*		*127*		159					
‡21	3668	*2853*	11255	*11430*				*130*		*131*		169					
‡22	3881	*3012*	12328	*12603*				*134*		*135*		178					
‡23	4100	*3177*	13477	*13853*				*138*		*139*		188					
‡24	4326	*3348*	14694	*15185*				*142*		*143*		197					
‡25	4558	*3525*	15991	*16600*				*146*		*147*		206					

Differences for

All.	None.	—81	+233	None.	+59	+76	None.

ROADS.

Bridge.

Formation Heights.	Each additional Span.								Area of Waterway, Superficial feet.	Notes, &c.
	Foundations, Cubic feet.		Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Parapets, Coping and String course. Running feet.		Starling Caps, No.	Centres.	
	Excavation,	Filling.								
	1	2	3	4	5	6 7 8		9		
Returned Walls.										
MENTAL ARCHES.										
6			387							50
7			455							65
8			523							80
9			591							95
10			659							110
11			727							125
12			795							140
13			863							155
14	526	423	931	502	19	35·5		2	For each centre required, repeat the quantities for single span. For number *see* page 387, Art. 18.	170
15			999							185
16			1067							200
17			1135							215
18			1203							230
19			1271							245
¶20			1411							260
¶21			1479							275
¶22			1547							290
¶23	561	475	1615							305
¶24			1683							320
¶25			1751							335
SEMICIRCULAR ARCHES.										
All.	None.		—132		None.					—10

S = 23
S′ = 17·75

* This is the average plan height, and all the quantities for it have been taken from a regular estimate.

† 121 cubic feet wood-work in centre is made up of 53 in ribs, and 68 in laggings and tie planks, &c.

• The semicircular difference + 59 is made up of
+ 31 for ribs, and
+ 28 for laggings.

‡ Quantities for these heights are increased for a counterfort 5 × 3 feet at centre of back of each abutment built up to within 5 feet of formation level.

¶ Quantities for these heights are increased for a plinth 5 feet high, projecting 3 inches all round pier.

If tie-beam of centre is scarfed, add to the "wood-work" in *segmental* centre, 1·5 cubic feet.

Wood-work rate is to include loss by wastage.

List of bolts in iron work of one rib of centres.

Segmental.	Semicircular.
8 Bolts 5″ × ¾″ sqr.	12 Bolts 5″ × ¾″ sqr.
2 „ 7″ × ¾″ „	6 „ 7″ × ¾″ „

20 FEET

20 Feet

Formation Heights.	Bridge of Single Span.											Centres.				
	Excavation, and Filling in, Foundations, Cubic feet.		Superstructure, Cubic feet.		Arching, Cubic feet.	Impost, Running feet.	Parapets, Running feet.		String course and Copings, Running feet.		Newal Caps, No.	Coping on Wings, Running feet.	Wood work { Ribs=80 c. ft; Laggings =90 c. ft. Cubic feet.	Iron work, lbs.	Sand Boxes, No.	Rafters, Running feet.	Removals, No.
	1	2	3		4	5	6		7	8	9	10	1	2	3	4	5
Design with 4ft	Wings.	Returned Walls.	Wings.	Returned Walls.	Wings or Returned Walls.		Wings.	Returned Walls.	Wings.	Returned Walls.	Wings.		Wings or				
													Quantities for				
8	1600	1440	2127	2050				92		93		47					
9	1715	1521	2586	2510				96		97		56					
10	1838	1608	3075	3008				100		101		66					
11	1975	1701	3602	3548				104		105		75					
12	2119	1800	4174	4134				108		109		84					
13	2270	1905	4783	4767				112		113		96					
14	2429	2016	5442	5447				116		117		103					
*15	2593	2133	6149	6190				120		121		112					
16	2764	2256	6904	6986				124		125		122					
17	2943	2385	7695	7841				128		129		131					
18	3128	2520	8570	8760				132		133		141					
19	3378	2661	9481	9743	811	16	72	136	73	137	4	150	1791†	66	10	..	1
20	3518	2808	10468	10798				140		141		159					
21	3723	2961	11511	11923				144		145		169					
22	3936	3120	12602	13124				148		149		178					
23	4155	3285	13769	14402				152		153		188					
24	4381	3456	15004	15762				156		157		197					
‡25	4703	3723	16889	17775				160		161		206					
‡26	4943	3906	18298	19336				164		165		216					
‡27	5189	4095	19787	20986				168		169		225					
‡28	5442	4290	21340	22730				172		173		234					
‡29	5703	4491	22985	24569				176		177		244					
‡30	6049	4693	24706	26508				180		181		253					
													Differences for				
All.	None.		— 114		355 +		None.						— 6	— 1	None.	+ 23	None.

ROADS.

Bridge.

Formation Heights.	Each Additional Span.								Area of Waterway, Superficial feet.	Notes, &c.
	Foundations, Cubic feet.		Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Parapets, Coping, String course. Running feet.	Starling Caps, No.	Centres.		
	Excavation,	Filling in,								
	1	2	3	4	5	6 7 8	2			
Returned Walls.										S = 30 S′ = 23
Segmental Arches.										
8			579						95	
9			659						115	
10			739						135	
11			819						155	
12			899						175	
13			979						195	
14			1059						215	
*15			1139						235	
16			1219						255	
17			1299						275	
18			1379						295	
19	558	443	1459	811	20	46	2	For each centre required repeat the quantities for a single span. For number, *see* page 387, Art. 16.	315	
20			1539						335	
21			1619						355	
22			1700						375	
23			1780						395	
24			1860						415	
§25			2014						435	
§26			2094						455	
§27			2174						475	
§28	614	500	2254						495	
§29			2334						515	
§30			2413						535	
Semicircular Arches.										
All.	None.		— 165	355 +	None.				— 18	

* *See* note to 15 feet Bridge.

† 179 cubic feet wood-work in centre is made up of
89 in ribs,
90 in laggings, &c.

The semicircular difference + 28 is made up of
— 6 for ribs, and
+ 34 for laggings, &c.

‡ The quantities for these heights are increased for a counterfort 5′ x 3 feet at centre of back of each abutment built up to within 6 feet of formation level.

§ *See* note to 15 feet Bridge.

If tie-beam of centre is scarfed, add to the "wood-work" in *segmental* centres 2 cubic feet.

"Wood-work" rate is to include loss by wastage.

List of Bolts in Iron-work of one rib of centres.

Segmental.	Semicircular.
8 Bolts 5″ × ½″ sqr.	8 Bolts 4″ × ½″ sqr.
2 ,, 8″ × ¾″ ,,	2 ,, 7″ × ¾″ ,,
3 ,, 9″ × ⅞″ ,,	2 ,, 6″ × ½″ ,,

20 FEET

25 Feet

Formation Heights.	Bridge of Single Span.														
	Foundations, Cubic feet.		Superstructure, Cubic feet.		4 Arching, Cubic feet.	5 Impost, Running feet.	6 Parapets, Running feet.	7 String course, 8 and Coping, } Running feet.		9 Newal Caps, No.	10 Coping on Wings, Running feet.	Centres.				
	1 Excavation,	2 Filling in,	3									1 Wood work, Cubic feet. { Ribs = 149, Laggings = 109.	2 Iron Work, lbs.	3 Sand Boxes, No.	4 Rafters, Running feet.	5 Removals, No.
Design with	Wings.	Returned walls.	Wings.	Returned walls.	Wings or Returned Walls.	Wings.	Returned Walls.	Wings.	Returned Walls.	Wings.		Wings or				
Quantities for																
10	1944	*1758*	3444	*3352*				*114*		*115*		66				
11	2131	*1851*	4019	*3938*				*118*		*119*		75				
12	2275	*1950*	4639	*4570*				*122*		*123*		84				
13	2426	*2055*	5296	*5240*				*126*		*127*		96				
14	2585	*2166*	6003	*5980*				*130*		*131*		103				
15	2749	*2283*	6758	*6764*				*134*		*135*		112				
16	2920	*2406*	7561	*7606*				*138*		*139*		122				
17	3099	*2535*	8400	*8507*				*142*		*143*		131				
18	3284	*2670*	9323	*9472*				*146*		*147*		141				
19	3534	*2811*	10282	*10501*				*150*		*151*		150				
20	3674	*2958*	11317	*11602*				*154*		*155*		159				
21	3879	*3111*	12408	*13773*				*158*		*159*		169				
22	4092	*3270*	13547	*14020*				*162*		*163*		178				
23	4311	*3435*	14762	*15344*	987	16	86	*166*	87	*167*	4	188	258	131	10	1
24	4537	*3606*	16045	*16750*				*170*		*171*		197				
25	4769	*3783*	17408	*18239*				*174*		*175*		206				
26	5009	*3966*	18835	*19816*				*178*		*179*		216				
27	5255	*4155*	20342	*21482*				*182*		*183*		225				
28	5508	*4350*	21913	*23242*				*186*		*187*		234				
29	5769	*4551*	23576	*25097*				*190*		*191*		244				
30	6205	*4848*	26005	*27742*				*194*		*195*		253				
31	6399	*5061*	27858	*29828*				*198*		*199*		263				
32	6679	*5280*	29799	*32020*				*202*		*203*		272				
33	6966	*5505*	31824	*34319*				*206*		*207*		281				
34	7260	*5736*	33949	*36730*				*210*		*211*		291				
35	7561	*5973*	36174	*39254*				*214*		*215*		300				
Differences for																
All.	None.		− 208		+448	None.						+19	− 42	+46	..	

ROADS.

Bridge.

Formation Heights.	Each Additional Span.								Area of Waterway, Superficia feet.	Notes, &c.
	1 Excavation, } Foundations, Cubic feet.	2 Filling in. }	3 Superstructure, Cubic feet.	4 Arching, Cubic feet.	5 Impost, Running feet.	6 Parapets, 7 Coping, 8 String course, } Running foot.	9 Starling Caps, No.	Centres.		
Returned Walls.										S = 37 S′ = 28·5
Segmental Arches.										
10			887						161	* *See* note to 15 feet Bridge.
11			982						186	
12			1076						211	† The number 258 cubic feet for woodwork in centre is made up of 149 in ribs, and 109 in laggings, &c.
13			1172						236	
14			1267						261	
15			1363						286	The semicircular difference + 19 is made up of — 28 for ribs, and + 47 for laggings, &c.
16			1458						311	
*17			1554						336	
18			1649						361	
19	866	670	1745	987	22	57	2	For each centre required repeat the quantities for a single span. Number required, *see* page 337, Art. 16.	386	‡ The quantities for these heights are increased for a counterfort 5′ × 3′ at centre of back of abutment, built up to within 7 feet of formation level.
20			1841						411	
21			1937						436	
22			2032						461	§ *See* note to 15 feet Bridge.
23			2128						486	
24			2224						511	If tie-beam of centre is scarfed, add to the "wood-work" in *segmental* centres, 2·5 cubic feet.
25			2319						536	
26			2416						561	"Wood-work" rate is to include loss by wastage.
27			2512						586	
28			2607						611	List of Bolts in Iron work of one rib of centres.
29			2703						636	Segmental. Semicircular.
§30			2873						661	10 Bolts 6″ × ½″ sqr. 12 Bolts 5″ × ½″ sqr.
§31			2969						686	9 ,, 9″ × 1″ ,, 6 ,, 8″ × ¾″ ,,
§32			3074						711	... 1 ,, 9″ × 1″ ,,
§33	938	735	3161						736	
§34			3257						761	
§35			3353						786	
Segmental Arches.										
All.	None.		— 202	+ 448	None.				— 28	

20 FEET

30 Feet

Formation Heights.	Bridge of Single Span.																
	Foundations, Cubic feet.		Superstructure, Cubic feet.		Arching, Cubic feet.	Impost, Running feet.	Parapets, Running feet.		String Course and Coping, Running feet.		Newal caps, No.	Coping on Wings, Running feet.	Centres.				
	Excavation, 1	Filling in, 2	3		4	5	6		7	8	9	10	Wood-work, Cubic ft. Ribs = 221, Lagging = 132. 1	Iron work, lbs. 2	Sand boxes, No. 3	Rafters, Running feet, 4	Removals, No. 5
Design with ☞	Wings	Returned walls.	Wings.	Returned walls.	Wings or Returned walls.		Wings.	Returned walls.	Wings.	Returned walls.	Wings.		Wings or				
													Quantities for Seg				
12	2428	*2100*	4788	*4738*				*136*		*137*		84					
13	2579	*2205*	5492	*5463*				*140*		*141*		96					
14	2738	*2316*	6246	*6240*				*144*		*145*		103					
15	2902	*2433*	7048	*7070*				*148*		*149*		112					
16	3073	*2556*	7898	*7958*				*152*		*153*		122					
17	3252	*2685*	8784	*8905*				*156*		*157*		131					
18	3437	*2820*	9754	*9916*				*160*		*161*		141					
19	3687	*2961*	10760	*10991*				*164*		*165*		150					
*20	3827	*3108*	11842	*12138*				*168*		*169*		159					
21	4032	*3261*	12980	*13355*				*172*		*173*		169					
22	4245	*3420*	14166	*14648*				*176*		*177*		178					
23	4464	*3585*	15428	*16018*				*180*		*181*		188					
24	4690	*3756*	16758	*17470*				*184*		*185*		197					
25	4922	*3933*	18168	*19005*				*188*		*189*		206					
26	5162	*4116*	19642	*20628*	1399	18	98	*192*	99	*193*	4	216	353†	174	10	..	1
27	5408	*4305*	21196	*22340*				*196*		*197*		225					
28	5661	*4500*	22814	*24146*				*200*		*201*		234					
29	5922	*4701*	24524	*26047*				*204*		*205*		244					
30	6268	*4908*	26310	*28048*				*208*		*209*		253					
31	6462	*5121*	28180	*30150*				*212*		*213*		263					
32	6742	*5340*	30138	*32358*				*216*		*217*		272					
33	7029	*5565*	32180	*34673*				*220*		*221*		281					
34	7323	*5796*	34322	*37100*				*224*		*225*		291					
‡35	7714	*6123*	37374	*40450*				*228*		*229*		300					
‡36	7986	*6366*	39734	*43138*				*232*		*233*		309					
‡37	8336	*6615*	42166	*45945*				*236*		*237*		319					
‡38	8658	*6870*	44722	*48876*				*240*		*241*		328					
‡39	8986	*7131*	47398	*51932*				*244*		*245*		337					
‡40	9320	*7398*	50370	*55118*				*248*		*249*		347					
													Differences for Semi				
All.	None.			−248	+608	None.							− 5	+6	..	+115	..

ROADS.

Bridge.

Formation Heights.	Each Additional Span.								Area of Waterway, Superficial feet.	Notes, &c.
	Foundations, Cubic feet.		Superstructure, Cubic feet.	Arching, Cubic feet.	Impost, Running feet.	Parapets Coping and String course, Running feet.	Starling Caps, No.	Centres.		
	Excavation, 1	Filling in, 2	3	4	5	6 7 8	9			
Returned Walls.										S =44 feet S′ =34 ,,
MENTAL ARCHES.										
12			1292						237	
13			1394						267	* *See* note to 15 feet Bridge.
14			1496						297	
15			1598						327	† 353 cubic feet for wood-work in centre is made up of 221 in ribs, and 132 in laggings, &c.
16			1700						357	
17			1802						387	
18			1904						417	The semicircular difference — 5 is made up of — 58 for ribs and + 53 for laggings, &c.
19			2006						447	
*20			2109						477	
21			2210						507	
22			2312						537	‡The quantities for these heights are increased for a counterfort 5′ × 3′ at the centre of back of abutment built up to within 8 feet of formation level.
23	1088	882	2414	1399	24	68	2	For each centre required repeat the quantities in a single span. For number see page 387, Art. 16.	567	
24			2516						597	
25			2618						627	¶ *See* note (§) to 15 feet Bridge.
26			2720						657	
27			2822						687	If the tie beam of centre is scarfed, add to the "wood-work" in *segmental* centres, 2·5 cubic feet.
28			2924						717	
29			3026						747	"Wood-work" rate is to include loss by wastage.
30			3128						777	
31			3230						807	List of Bolts in Iron work of one rib of centres.
32			3332						837	Segmental. 12 Bolts 6″ × ⅛″ sqr.; 4 ,, 8″ × ⅛″ ,,; 1 ,, 9″ × 1″ ,,; 2 ,, 11″ × 1″ ,,
33			3434						867	Semicircular. 12 Bolts 5″ × ¼″ sqr.; 4 ,, 8″ × ¼″ ,,; 4 ,, 9″ × ⅝″ rnd.; 3 ,, 9″ × 1″ sqr.
34			3536						897	
¶35			3717						927	
¶36			3819						957	
¶37	1173	960	3921						987	
¶38			4023						1017	
¶39			4125						1047	
¶40			4227						1077	
CIRCULAR ARCHES.										
All.	None.		— 251	+ 608		None.			—41	

TABLE II. PART II.

QUANTITIES IN A VERTICAL SECTION

OF

1 FOOT IN LENGTH OF BRIDGES,

CALCULATED FOR

ALL FORMATION HEIGHTS,

USED AS SUPPLEMENTARY TO TABLE I. FOR INCREASED LENGTHS OF BRIDGES.

LENGTH OF ABUTMENTS, 1 FOOT.

1 FOOT IN LENGTH OF 15 FEET BRIDGE.

Formation Height.	Bridge of a Single Span.				Formation Height.	Each additional Span.				Notes, &c.
	Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.†		Excavation of Foundations, Cubic feet.	Filling in of Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.	
Quantities for Segmental Arches.											
6	30	25·35	21·8	+ or − ⅛ cost of centre for a 20 feet road; or, + or − quantities in 1 × rib for every 5 feet + or − in length, and ⅛ quantities in laggings, ties, &c. (Table I.) per each foot + or − in length.	6	17·25	14·25	10·68	21·8	Same as in column for single span.	
7		33·35			7			13·43			
8		41·35			8			16·18			
9		49·35			9			18·93			
10		57·35			10			21·68			
11		65·35			11			24·43			
12		73·35			12			27·18			
*13		81·35			*13	17·3	14·3	29·93			* Quantities for this height taken from estimate made of average plan.
14		89·35			14			32·68			
15		97·35			15			35·43			† Quantities in 1 rib:—
16		105·35			16			38·18			Segmental centre. 10·5 c. f. s. c. difference. +6·3
17		113·35			17			40·93			Wood-work.. Iron-work ... 5 lbs. +15
18		121·35			18			43·68			Sand boxes.. 2 No. × 0
19		129·35			19			46·43			
20		137·35			‡20	18·8	15·8	51·68			‡ Quantities for these heights increased for plinth.
21		145·35			‡21			54·43			
22		153·35			‡22			57·18			
23		161·35			‡23			59·93			
24		169·35			‡24			62·68			
25		177·35			‡25			65·43			
Differences for Semicircular Arches.											
All.	None.	− 4·25	+ 10·1	*See* Note.†	All.	None.	− 4·75	+ 10·1			

1 FOOT IN LENGTH OF 20 FEET BRIDGE.

Formation Height.	Bridge of Single Span.				Formation Height.	Each additional Span.				Notes, &c.
	Excavation, Filling in, } Foundations, Cubic feet.	Superstructure, Cubic feet,	Arching, Cubic feet.	Centre.†		Excavation of Foundations, Cubic feet.	Filling in of Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.	
					Quantities for Segmental Arches.					
8	36	40·4	35·3	+ or − ⅓ cost of centre for a 20 feet road; or, + or − quantities in 1 rib for every 5 feet + or − in length, and ⅓ quantities in laggings, ties, &c. (Table I.) per each foot + or − in length.	8	18	15	14·4	35·3	Same as in column for single span.
9		50·4			9			17·4		
10		60·4			10			20·4		
11		70·4			11			23·4		
12		80·4			12			26·4		
13		90·4			13			29·4		
14		100·4			14			32·4		
*15		110·4			*15			35·4		
16		120·4			16			38·4		
17		130·4			17			41·4		
18		140·4			18			44·4		
19		150·4			19			47·4		
20		160·4			20			50·4		
21		170·4			21			53·4		
22		180·4			22			56·4		
23		190·4			23			59·4		
24		200·4			24			62·4		
25		210·4			‡25	19·5	16·5	67·9		
26		220·4			‡26			70·9		
27		230·4			‡27			73·9		
28		240·4			‡28			76·9		
29		250·4			29			79·9		
30		260·4			‡30			82·9		

* Quantities for this height taken from estimate made of average plan.

† Quantities in 1 rib :—

	s. c. difference.
Wood-work. 17·8 c. f.	− 1·2
Iron-work... 12·5 lbs.	0
Sand boxes.. 2 No.	0

‡ Quantities for these heights increased for plinth.

Differences for Semicircular Arches.

All.	None.	− 6·4	+ 15·5	*See* Note†	All.	None.	− 4·25	+ 15·5	

1 FOOT IN LENGTH OF 25 FEET BRIDGE.

Formation Height.	Bridge of Single Span.				Formation Height.	Each additional Span.				Notes, &c.
	Excavation, } Foundations, Filling in, } Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.†		Excavation of Foundations, Cubic feet.	Filling in of Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.	
					Quantities for Segmental Arches.						
10		70·9			10			27·2			
11		82·9			11			30·7			
12		94·9			12			34·2			
13		106·9			13			37·7			
14		118·9			14			41·2			
15		130·9			15			44·7			
16		142·9			16			48·2			
*17		154·9			*17			51·7			
18		166·9			18			55·2			
19		178·9			19			58·7			
20		190·9			20	26·3		62·2			*See note to 15 feet Bridge, page 402.
21		202·9			21			65·7			
22		214·9			22			69·2			†Quantities in 1 rib :—
23	42	226·9	42·9	+ or − $\frac{1}{25}$ cost of centre for a 20 feet road; or, + or − quantities in 1 rib for every 5 feet + or − in length, and $\frac{2}{25}$ quantities in laggings, ties, &c. (Table I.) per each foot + or − in length.	23			72·7	42·9	Same as in column for single span.	s. c. difference.
24		238·9			24			76·2			Wood-work, 29·9c.ft. −5·6
25		250·9			25			79·7			Iron-work... 25·5 lbs. −8·5
26		262·9			26			83·2			Sand boxes.. 2 No. 0
27		274·9			27			86·7			
28		286·9			28			90·2			‡ Quantities for these heights increased for plinth.
29		298·9			29			93·7			
30		310·9			‡30			99·7			
31		322·9			‡31			103·2			
32		334·9			‡32			106·7			
33		346·9			‡33	28	23	110·2			
34		358·9			‡34			113·7			
35		370·9			‡35			117·2			
					Differences for Semicircular Arches.						
All.	None.	−12·7	+19·5	*See* Note†	All.	None.		−6·5	+19·5		

1 FOOT IN LENGTH OF 30 FEET BRIDGE.

Formation Height.	Bridge of Single Span.				Formation Height.	Each additional Span.				Notes, &c.
	Excavation, } Foundations, Filling in, } Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.†		Excavation of Foundations, Cubic feet.	Filling in of Foundations, Cubic feet.	Superstructure, Cubic feet.	Arching, Cubic feet.	Centre.	
				Quantities for Segmental Arches.						
12	48	95·3	60·8	+ or − ⅕ cost of centre for a 20 feet road; or, + or − quantities in 1 rib for every 5 feet + or − in length, and ⅕ quantities in laggings, ties, &c. (Table I.) per each foot + or − in length.	12	32	27	35·1	60·8	Same as in column for single span.
13		109·3			13			39·1		
14		123·3			14			43·1		
15		137·3			15			47·1		
16		151·3			16			51·1		
17		165·3			17			55·1		
18		179·3			18			59·1		
19		193·3			19			63·1		
*20		207·3			*20			67·1		
21		221·3			21			71·1		
22		235·3			22			75·1		
23		249·3			23			79·1		
24		263·3			24			83·1		
25		277·3			25			87·1		
26		291·3			26			91·1		
27		305·3			27			95·1		
28		319·3			28			99·1		
29		333·3			29			103·1		
30		347·3			‡30			109·6		
31		361·3			‡31			113·6		
32		375·3			‡32			117·6		
33		389·3			‡33			121·6		
34		403·3			‡34			125·6		
35		417·3			‡35	34	29	129·6		
36		431·3			‡36			133·6		
37		445·3			‡37			137·6		
38		459·3			‡38			141·6		
39		473·3			‡39			145·6		
40		487·3			‡40			149·6		
				Differences for Semicircular Arches.						
All.	None.	−1½	+26·5	See Note†	All.	None.	−5·2	+26·5	...	

* Quantities for this height taken from estimate made of average plan.

† Quantities in 1 rib :—

	s. c. difference.
Wood-work, 44·2 c. ft.	−11·5
Iron-work, 34 lbs.	+ 1
Sand boxes, 2 No.	0

‡ Quantities for these heights increased for plinth.

APPENDIX TO PART II.

PART II.—WING WALLS.

Using a similar method of calculation to that in Part I., we find the length depends on the ratio of the slope of the embankment, *i. e.* $l = 1{\cdot}5\ (H - 3)$, and B depends on the angle of splay, ϕ = BDA (*Fig.* 4, in *Plate* XLVIII., Part II.), and the square breadth which is fixed by design = BD + EG + GH = $\frac{H}{12} + t + \frac{H}{6}$

AC the breadth B_h = AD + DG + GC, but

$$AD = BD \frac{\sin ABD}{\sin BAD};\ DG = \frac{EG}{\sin \phi};\ GC = GH \frac{\sin GHC}{\sin GCH}$$

Sin ABD = sin (90 + α) = sin 92° 15′ = ·999 Sin ϕ = sin 45° = ·707

Sin BAD = sin (ϕ − α) = sin 42° 45′ = ·678 Sin GCH = sin (ϕ − β) sin 49° 30′ = ·76

Sin GHC = sin (90 − β) = sin 85° 30′ = ·997

for $\alpha°$ and $\beta°$ are the angles produced by the batter (*see Fig.* 4).

$\alpha = \frac{1}{2}\beta$; and $\tan \alpha = \frac{BD}{\text{length of wall}} = \frac{H}{12\ L}$; but $L = l \sec \phi \therefore {\cdot}039 = \tan \alpha$.

Wherefore

$\alpha° = 2°\ 15'$ and $\beta° = 4°\ 30'$. The above being the data.

Whence

AD = ·1225 H, DG = 2·1213, and GC = ·2185 H,

Therefore

$$B_h = {\cdot}341\ H + 2{\cdot}121$$

The area at shoulder $A_h = \left(\frac{B + 2{\cdot}121}{2}\right) H = {\cdot}171\ H^2 + 2{\cdot}12\ H$, nearly.

The area at the newal end, where height = H = 3, is $a = 7{\cdot}9$, nearly.

The middle area = area due to height $\frac{H-3}{2} = A_m = {\cdot}0426\ H^2 + 1{\cdot}316\ H + 3\ 31$.

Whence

The Prismoidal, or true mean area = $A_p = \frac{A_h + A_m + a}{6} = {\cdot}057\ H^2 + 1{\cdot}23\ H + 3{\cdot}7$, nearly; and multiplying by l, we have the content C of the body of the wing.

The rest of the wing wall is the *Buttress* joining it on to the abutment. This stands on the base CGILMK (*Fig.* 4, *Plate* XLVIII., Part II.), and is made up of a *Triangular Pyramid* and a *Wedge.*

The base of the *triangle* = $\frac{CG \times GK}{2}$ = ·2185 H × CG tan 49° 30′ = $\frac{25582\ H \times {\cdot}2185\ H}{2}$ = ·028 H^2, nearly; this by $\frac{H}{3}$ = content of pyramid = ·0093 H^3.

The content of the *wedge* is half its height multiplied by KI × MK; but by construction MK = 3 and KI is the batter due to the wall (·256 H)

from the point where it springs out of the vertical wall; this occurs at a height from the base, of H − 9·8 nearly, because 9·8 is the height due to a batter of 2·5 feet ∴ KI × MK = 3 × ·256 (H − 9·8) ∴ the content = ·384 (H − 9·8)² nearly ∴ c = 0093 H^3 + ·384 (H − 9·8)².

The breadth B′ of the base of the *Foundations* of body of wing, or wing proper, is 9 inches on the square, or 1·11 feet on the skew, greater than the breadth of the base of the superstructure, and the areas, a', of the bases of the pyramid and wedge are the same as those of the superstructure; and are, as above = ·028 H^2 + ·768 (H − 9·8), which, multiplied by the depth 3, gives the content, C.

The following is a table of the values of the equations 2·3 (H − 9·8) and ·384 (H − 9·8)², multiplied by 4, to obtain the quantities in a Bridge; which may be used to make deductions when the design is changed by the omission of the pilasters and returns, *vide* Art. 6, page 385.

TABLE G.

Height of Formation.	Foundations, Cubic feet.	Superstructure, Cubic feet.	Height of Formation.	Foundations, Cubic feet.	Superstructure, Cubic feet.
10	2	·1	26	149	493
11	11	2·2	27	159	454
12	20	7·6	28	168	509
13	30	16	29	177	566
14	39	27	30	186	627
15	48	42	31	195	690
16	57	59	32	204	757
17	66	80	33	213	827
18	76	103	34	223	900
19	85	130	35	232	975
20	94	160	36	241	1054
21	103	192	37	250	1136
22	112	228	38	259	1222
23	122	268	39	269	1310
24	131	310	40	278	1400
25	140	355			

Tables H., I., J., are used to frame Table I., Part II., as described in page 356, Art. 43, Part I.

EXAMPLES ON TABLES H. AND I.

1. When the ground on which a wing is founded slopes upward, the wing will be shortened, as shown by dotted lines in *Fig.* 3, *Plate* XLVIII., Part II.

There are two ways of calculating the contents of such a wing.

One, by assuming a give and take plane along the foundations from the shoulder to the newal; the other, by taking out each step separately. The Tables will facilitate the calculations either way, but the first will give the most practical approximation, especially when the steps are *frequent* and *small*. Call x the height of the end of wall over the level of the base at shoulder of wing.

The mean area will be that due to the height H; but the length *(l)* will be that due to the height, $H - x$; for the values of these, *see* Tables, columns A_p' and l:—

Let $x = 10$; $H = 20$; $H - x = 10$.

Then area due to $H = 51{\cdot}1$; length due to $H - x = 10{\cdot}5$; and content $51{\cdot}1 \times 10{\cdot}5 = 536{\cdot}5$.

In *foundations*, mean breadth for 20 feet $= \frac{\text{Area}}{\text{length}} = \frac{182{\cdot}4}{25{\cdot}5} = 7{\cdot}15$; length $= 10{\cdot}5$ $\therefore$ content $= 75 \times 3 = 225$.

2. The quantities by the second method are obtained by deducting the quantities due to a wall of the height of the ends, at the several steps, from the quantities due to the shoulder-heights; thus, if we have a wall built in 2 steps, as shown in *Fig.* 3, by dotted lines; the first step being at a point in the wall 16 feet high; and the rise of the step being 10 feet;

Then—

Content due to 20 feet = 1303 c. ft.
less content due to 16 „ = 741
} $\therefore$ content of 1st block = 562 c. ft.

and content due to 6 „ = 59 $\therefore$ content of end block = 59

Total content of wall, = 621

The content of *Foundations* = 547 + 378 + 64 = 989 cubic feet.

This method is the more accurate one when the steps are *few* and *large*.

3. When the approaches of a Bridge have other ratio (r') of slope, than $1\frac{1}{2}$ to 1, or, θ' other than 33° 41′.

The content of a wing = *Tabular content* $\times \frac{r'}{1{\cdot}5}$ = Tabular content $\times \frac{\cot \theta''}{\cot 33{\cdot}41.}$

4. When a wing has other splay ϕ' than 45°; or 1 to 1,

The content of a wing = Tabular content $\times \frac{\sec \phi'}{1{\cdot}414}$

5. When a wing has other splay and approaches other slopes,

The content of the wing = Tabular content $\times \frac{r' \times \sec \phi'}{2{\cdot}121}$

TABLE H., BRIDGES.—PART II.
Foundations of Wing-walls *(Splayed)*.

Height of Formation.	Body of Wings in front of Face of Bridge.						Shoulders.		Total net content of 4 wings, and shoulder buttresses.	Notes, &c.
	Breadths at shoulder. B'.	Gross area. A'.	Gross content of one. A'' × 3.	Deduct – for overlap of foundations of pilaster. Area. O'.	Content.	Net content of one.	Area of one shoulder. a'	Content of one shoulder.		
6	5·28	21·45	64·3	3·25	9·7	54·6	1·0	3·0	230	
7	5·62	29·62	88·9	3·37	10·1	78·8	1·4	4·2	332	
8	5·961	38·30	114·9	3·50	10·5	104·4	1·8	5·4	439	
9	6·302	47·49	142·5	3·62	10·9	131·6	2·3	6·9	554	
10	6·642	57·20	171·6	3·75	11·2	160·4	2·9	8·8	677	
11	6·983	67·41	202·2	3·87	11·6	190·6	4·3	12·9	814	
12	7·324	78·14	234·4	4·00	12·0	222·4	5·7	17·2	958	
13	7·665	89·38	268·1	4·12	12·4	255·7	7·2	21·6	1109	
14	8·006	101·13	303·4	4·25	12·7	290·7	8·7	26·2	1268	
15	8·347	113·40	340·2	4·37	13·1	327·1	10·3	30·9	1432	
16	8·688	126·17	378·5	4·50	13·5	365·0	11·9	35·8	1603	
17	9·029	139·46	418·4	4·62	13·9	404·5	13·6	40·9	1782	
18	9·370	153·26	459·8	4·75	14·2	445·6	15·4	46·1	1967	B' is the skew breadth of foundation of wall on line AC, (*Fig.* 4) = ·341 H + 3·231, is made up of the breadth of superstructure base + 1·111. The breadth at small end is constant and = 4·253.
19	9·711	167·57	502·7	4·87	14·6	502·7	17·2	51·5	2217	
20	10·052	182·37	547·1	5·00	15·0	532·1	19·0	57·1	2357	
21	10·393	197·72	593·2	5·12	15·4	577·8	20·9	62·8	2562	
22	10·734	213·55	640·6	5·25	15·7	624·9	22·9	68·8	2775	
23	11·075	229·92	689·8	5·37	16·1	673·7	24·9	74·8	2994	A' is the total horizontal area of wing in front of face line of drain.
24	11·416	246·78	740·3	5·50	16·5	723·8	27·0	81·1	3220	
25	11·757	264·16	792·5	5·62	16·9	775·6	29·2	87·5	3452	O' = area of part of pilaster overlapping wing in *Fig.* 4 $= \frac{H}{8} + 2·5$, nearly.
26	12·098	282·05	846·1	5·75	17·2	828·9	31·4	94·1	3692	
27	12·439	300·45	901·3	5·87	17·6	883·7	33·6	100·9	3938	a' the area of the buttress at the shoulder.
28	12·780	319·35	958·0	6·00	18·0	940·0	35·9	107·8	4191	
29	13·121	338·79	1016·4	6·12	18·4	998·0	38·3	114·9	4452	The lengths *l* and L are the same as in superstructure in Table I.
30	13·462	358·71	1076·1	6·25	18·7	1057·4	40·7	122·1	4798	
31	13·803	379·17	1137·5	6·37	19·1	1118·4	43·2	129·6	4992	
32	14·144	400·13	1200·4	6·50	19·5	1180·9	45·7	137·2	5272	
33	14·485	421·60	1264·8	6·62	19·9	1244·9	48·3	144·9	5559	
34	14·826	443·58	1330·7	6·75	20·2	1310·5	50·9	152·8	5853	
35	15·167	466·08	1398·2	6·87	20·6	1377·6	53·6	160·9	6154	
36	15·508	486·06	1458·2	7·00	21·00	1437·2	56·4	169·2	6426	
37	15·849	512·60	1537·8	7·12	21·4	1516·4	59·2	177·7	6776	
38	16·190	536·60	1609·8	7·25	21·7	1588·1	62·1	186·3	7098	
39	16·531	561·17	1683·5	7·37	22·1	1661·4	65·0	195·0	7426	
40	16·872	586·19	1758·6	7·50	22·5	1736·1	68·0	204·0	7760	

TABLE I. BRIDGES.—PART II.

Superstructure of Wing Walls (*Splayed*).

Height of Formation. H.	Body of Wing in front of face of Bridge. Breadths of base at shoulder. B_h.	Lengths perpendicular to face of bridge. l.	Lengths on axis of wing. L.	Prismoidal, or true mean areas. Ap.	Content of one wing (body). C.	Shoulder. Content of one buttress. c.	Total content of a wing and shoulder buttresses. 4 (C+c)	Notes, &c.
6	4·17	4·5	6·36	13·1	59	2·0	244	
7	4·51	6·0	8·48	15·1	91	3·2	377	
8	4·85	7·5	10·61	17·2	129	4·8	535	
9	5·191	9·0	12·73	19·4	175	6·8	727	
10	5·531	10·5	14·85	21·7	228	9·3	949	
11	5·872	12·0	16·97	24·1	289	13	1209	
12	6·213	13·5	19·09	26·7	360	18	1514	
13	6·554	15·0	21·21	29·3	440	24	1856	
14	6·895	16·5	23·33	32·1	530	32	2248	
15	7·236	18·0	25·45	35·0	630	42	2688	
16	7·577	19·5	27·57	38·0	741	53	3176	
17	7·918	21·0	29·69	40·9	859	66	3700	
18	8·259	22·5	31·82	44·3	997	80	4308	
19	8·600	24·0	33·94	47·6	1142	96	4952	
20	8·941	25·5	36·06	51·1	1303	115	5672	
21	9·282	27·0	38·18	54·7	1477	135	6448	
22	9·623	28·5	40·30	58·3	1662	156	7272	
23	9·964	30·0	42·42	62·1	1863	180	8172	
24	10·306	31·5	44·54	66·0	2079	206	9140	
25	10·646	33·0	46·66	70·1	2313	234	10188	
26	10·987	34·5	48·78	74·2	2560	265	11300	
27	11·328	36·0	50·90	78·5	2826	297	12492	
28	11·669	37·5	53·02	82·8	3105	332	13748	
29	12·010	39·0	55·15	87·3	3405	369	15096	
30	12·351	40·5	57·27	91·9	3722	408	16520	
31	12·692	42·0	59·39	96·6	4057	450	18028	
32	13·033	43·5	61·51	101·4	4411	495	19624	
33	13·374	45·0	63·63	106·3	4784	542	21304	
34	13·715	46 5	65·75	111·4	5180	591	23084	
35	14·056	48·0	67·87	116·6	5597	644	24964	
36	14·397	49·5	69·99	121·2	6034	699	26932	
37	14·738	51·0	72·11	127·2	6487	756	28972	
38	15·079	52·5	74·23	132·7	6967	817	31136	
39	15·420	54·0	76·35	138·4	7474	881	33420	
40	15·761	55·5	78·47	145·1	8053	947	36000	

B', A_h A_p, are skew measurements; that is, they are taken on the line parallel to the face of the bridge or 45° from line of axis of wing.

The skew breadth of top of wall .. .. = 2·121
Face batter, .. = ·1225 H
Back ,, .. = ·2185 H
l = 1·5 (H — 3),
L = 1·5 (H — 3) secant ϕ^c.
The content of the shoulder buttress (c) is made up of a pyramid and a wedge.

TABLE J. BRIDGES.—PART II.

Returned Wails.

Height of Formation. H.	Foundations. Length of one.	Foundations. Breadth of base.	Foundations. Area of one.	Foundations. Content of four.	Superstructure. Length of one.	Superstructure. Breadth of base. B.	Superstructure. Area of one. A.	Superstructure. Content of four.	Notes, &c.
6	7	3·75	26·25	315	6	3·00	13·50	324	
7	8	4·00	32·00	384	7	3·25	16·62	465	
8	9	4·25	38·25	459	8	3·50	20·00	640	
9	10	4·50	45·00	540	9	3·75	23·63	851	
10	11	4·75	52·25	627	10	4·00	27·50	1100	
11	12	5·00	60·00	720	11	4·25	31·62	1391	
12	13	5·25	68·25	819	12	4·50	36·00	1728	
13	14	5·50	77·00	924	13	4·75	40·62	2112	
14	15	5·75	86·25	1035	14	5·00	45·50	2548	
15	16	6·00	96·00	1152	15	5·25	50·62	3037	
16	17	6·25	106·25	1275	16	5·50	56·00	3584	
17	18	6·50	117·00	1404	17	5·75	61·62	4190	
18	19	6·75	128·25	1539	18	6·00	67·50	4860	These walls are formed by returning the headwalls of the Bridge back. The walls have the same amount of sectional area as the splayed wings, *see* Drawing, *Fig.* 7.
19	20	7·00	140·00	1680	19	6·25	73·60	5594	
20	21	7·25	152·25	1827	20	6·50	80·00	6400	
21	22	7·50	165·00	1980	21	6·75	86·62	7276	
22	23	7·75	178·25	2139	22	7·00	93·50	8228	The length is taken from the back of the abutment. The area of the foundations is the horizontal area. The area of the superstructure is the vertical area = $\left(\frac{B+1·5}{2}\right).H = (\frac{7}{8}\,H+1·5)H.$ Breadth of base B = ·25 H + 1·5 for superstructure; and = ·25 H + 2·25, or B + ·75 for foundations.
23	24	8·00	192·00	2304	23	7·25	100·62	9257	
24	25	8·25	206·25	2475	24	7·50	108·00	10368	
25	26	8·50	221·00	2652	25	7·75	115·62	11562	
26	27	8·75	236·25	2835	26	8·00	123·50	12844	
27	28	9·00	252·00	3024	27	8·25	131·62	14215	
28	29	9·25	268·25	3219	28	8·50	140·00	15680	
29	30	9·50	285·00	3420	29	8·75	148·62	17240	
30	31	9·75	302·25	3627	30	9·00	157·50	18900	
31	32	10·00	320·00	3840	31	9·25	166·62	20661	
32	33	10·25	338·25	4059	32	9·50	176·00	22528	
33	34	10·50	357·00	4284	33	9·75	185·62	24502	
34	35	10·75	376·25	4515	34	10·00	195·50	26588	
35	36	11·00	396·00	4752	35	10·25	205·62	28787	
36	37	11·25	416·25	4995	36	10·50	216·00	31104	
37	38	11·50	437·00	5244	37	10·75	226·62	33540	
38	39	11·75	458·25	5499	38	11·00	237·50	36100	
39	40	12·00	480·00	5760	39	11·25	248·62	38785	
40	41	12·25	502·25	6027	40	11·05	260·00	41600	

When laying out a bridge, one of the simplest methods of giving the lines of a wing wall will be :—

Lay down the face line of the superstructure (line of head-walls, or pilasters, as the case may be), AC in *Figs.* 4, 4*a*, *Plate* XLVIII., Part II., on this set off GK ; and from G lay off DG the breadth of top wall (2·121 feet) and also the length DA taken from *Fig.* 6. A is the point where the toe of the wing joins the face of the bridge.

From this point lay off lines perpendicular and parallel to face of bridge, as in *Fig.* 2, which will give the position of the newal.

The line of foundations is then set off at a perpendicular distance outwards, of 9 inches from the above line of the base of superstructure of wing.

The following Table is useful in finding the slope of top of wing, and is got from the following—

Length of wing perpendicular of axis of road $l = H \cot \theta$,

,, on its own axis, $L = l \sec \phi$,

Angle of splay $= \phi°$,

Angle of slope of bank $= \theta°$,

Angle top of wall makes with the vertical on its own axis $= \chi°$,

Tan $\chi° = \frac{L}{H} = \frac{1}{\cot \theta \cdot \sec \phi}$; and r = ratio of horizontal setting back of face of wing to length l.

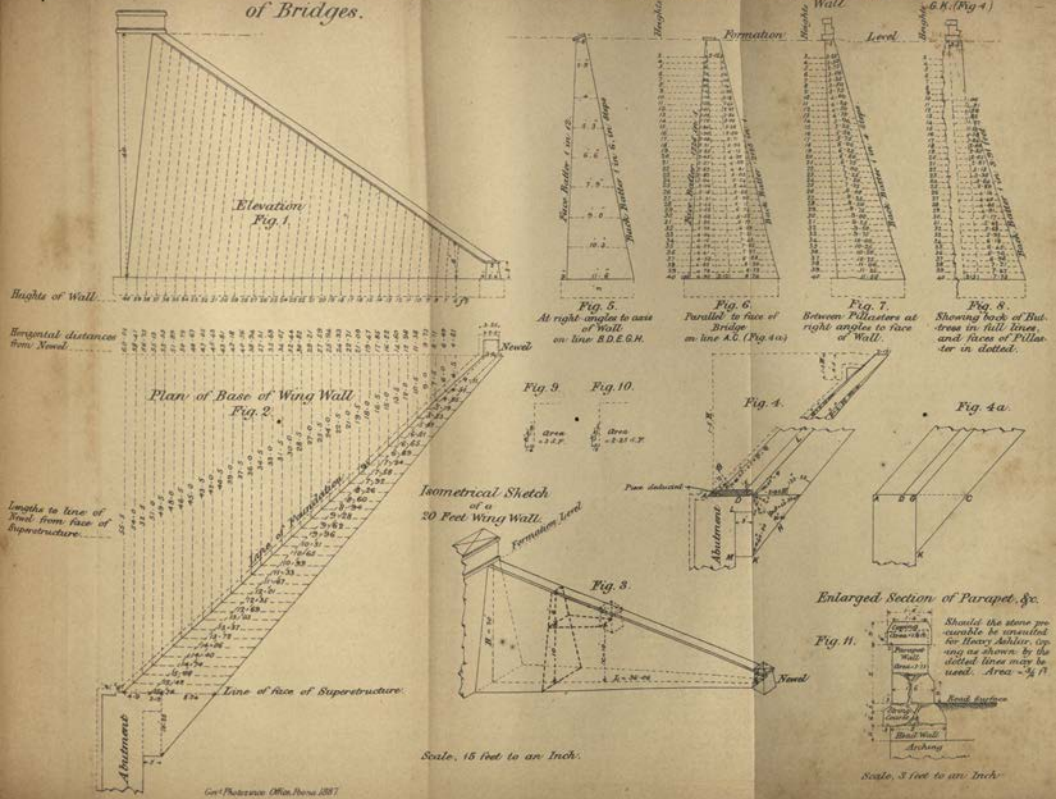
Cols. 4, 6, 8, 10, 12, *give lengths measured horizontally on axis of wing in which top of wall falls* 1 *foot.*

TABLE K.

Splays.		Slopes of Banks.										
r	$\phi°$	θ = 45° 1 Hor. to 1 Ver.		θ = 38° 39′ 1¼ Hor. to 1 Ver.		θ = 33° 41′ 1½ Hor. to 1 Ver.		θ = 29° 44′ 1¾ Hor. to 1 Ver.		θ = 26° 34′ 2 Hor. to 1 Ver.		Sec $\phi°$
		$\chi°$	tan χ	$\chi°$	tan χ	χ	tan χ	χ	tan χ	χ	tan χ	
	° ′	° ′		° ′		° ′		° ′		° ′		
¼ to 1	14 4	45 52	1·031	52 12	1·288	57 8	1·548	61 00	1·805	64 80	2·062	1·031
½ to 1	26 34	48 12	1·118	54 26	1·398	59 13	1·678	62 56	1·957	65 55	2·237	1·118
¾ to 1	36 52	51 20	1·250	57 27	1·567	61 56	1·876	65 26	2·188	81 2	2·5	1·25
1 to 1	45°	54 44	1·414	60 32	1·770	64 46	2·121	68 00	2·475	70 30	2·825	1·414
1¼ to 1	51 21	58 0	1·600	63 29	2·004	67 25	2·407	70 21	2·801	72 40	3·205	1·601
1½ to 1	56 19	60 55	1·800	66 20	2·252	69 45	2·710	72 25	3·155	74 31	3·61	1·8
1¾ to 1	60 16	63 37	2·015	68 21	2·519	71 44	3·030	74 12	3·534	76 4	4·032	2·02
2 to 1	63 26	65 51	2·230	70 18	2·793	73 25	3·356	75 41	3·922	77 22	4·464	2·23
Cotan $\theta°$		1·0		1·25		1·5		1·75		2·0		

General Drawings of Wing Walls of Bridges.

Plate XLVIII.



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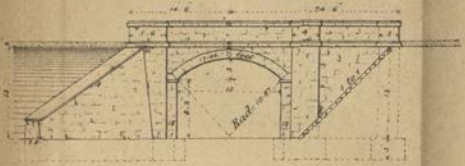
15 Feet Bridge.

Plate XLIX.

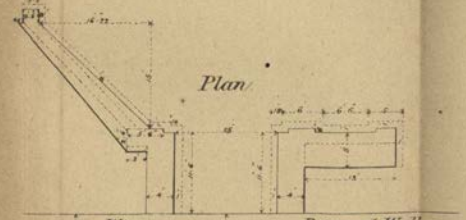
Single Span.

Segmental Elevation.



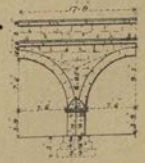
Semicircular Elevation.

Plan.



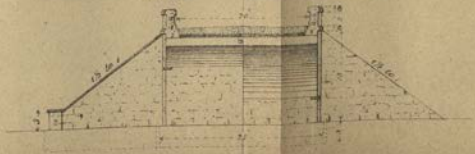
Each Additional Span.

Semicircular.



Segmental.

Section.



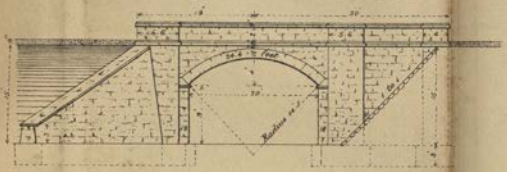
Scale, 15 feet to an Inch.

20 Feet Bridge.

Plate L.

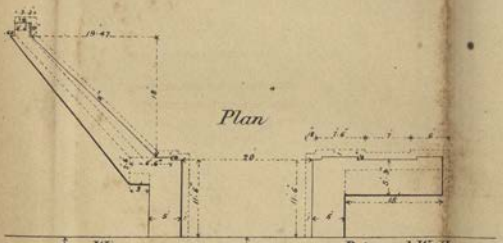
Single Span.

Segmental Elevation.



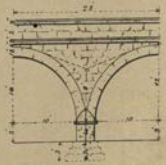
Semicircular Elevation.

Plan.



Each Additional Span.

Semicircular



Segmental

Section.

Scale, 15 feet to an Inch.

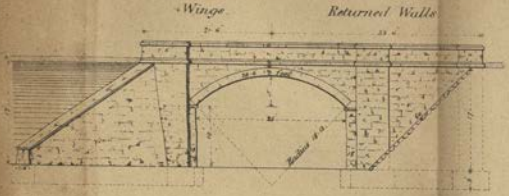
Govt. Photozincoe Office, Poona, 1887.

25 Feet Bridge.

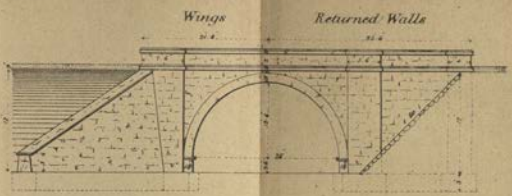
Plate LI

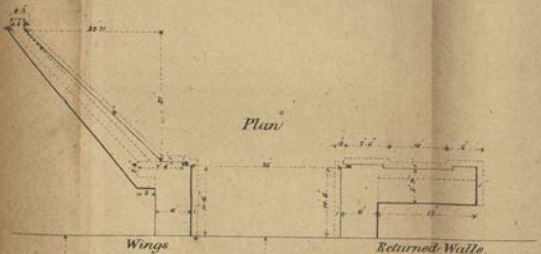
Single Span.

Segmental Elevation.



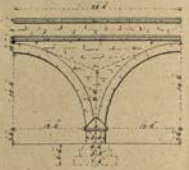
Semicircular Elevation.



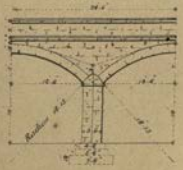


Each Additional Span.

Semicircular



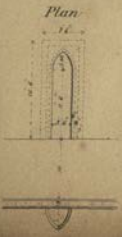
Segmental



Scale. 15 feet to an Inch

Parapet Wall

Plan

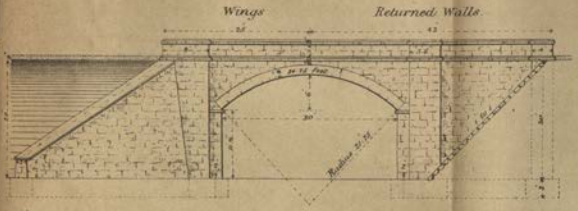


30 Feet Bridge.

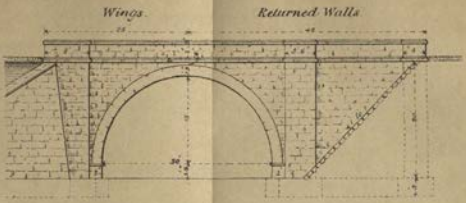
Plate LII.

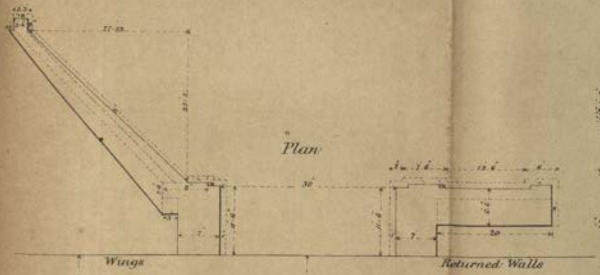
Single Span.

Segmental Elevation.



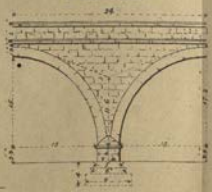
Semicircular Elevation.



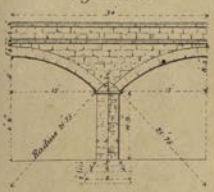


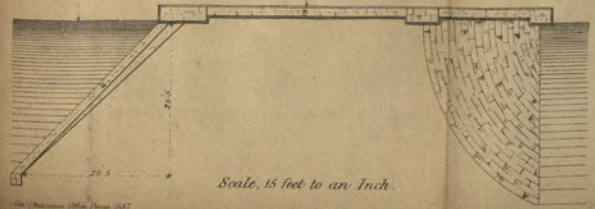
Each Additional Span.

Semicircular

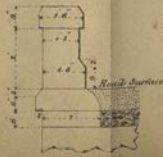


Segmental.

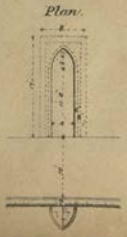




Parapet Wall.



Plan.



Sloping length of wing in which top falls 1 foot = sec χ°.

The area of pitching round the ends of the slopes of Bridges with *returned walls, vide* Art. 1, page 384, is given in the following table.

It is assumed that the slope along the walls is 1 to 1, and where the pitching joins the embankment is $1\frac{1}{2}$ to 1; that is to say, the surface of the pitching would be that of one quarter of an elliptical cone. For a practical approximation we may calculate the slant height from 1·25 H as a mean radius; hence the area = 1·575 H^2.

TABLE L.

PITCHING OF SLOPES.

Formation Heights.	AREAS FOR		Formation Heights.	AREAS FOR		Formation Heights.	AREAS FOR		Formation Heights.	AREAS FOR	
	One.	Four.		One.	Four.		One.	Four.		One.	Four.
6	56·7	227	15	354·4	1418	24	907·2	3629	33	1715·2	6861
7	77·2	309	16	403·2	1613	25	984·4	3938	34	1820·7	7283
8	115·8	463	17	455·2	1821	26	1064·7	4259	35	1923·8	7718
9	127·6	510	18	510·3	2041	27	1148·2	4593	36	2041·2	8165
10	157·5	630	19	568·6	2274	28	1234·8	4939	37	2156·2	8625
11	190·6	762	20	630·0	2520	29	1324·6	5298	38	2274·3	9097
12	226·8	907	21	694·6	2778	30	1417·5	5670	39	2395·5	9582
13	266·2	1065	22	762·3	3049	31	1513·6	6054	40	2520·0	10080
14	308·7	1235	23	833·2	3333	32	1612·8	6451			

Memorandum for the guidance of Subordinates on the preparation of a Road Project in accordance with the rules of the Public Works Department.

SURVEY AND FIELD WORK.

1. Examine the *adjustment* of the *instruments*, and test the *length* of the *chain* before commencing survey.

2. *Choose* the *best* line for the road according to the usual rules, paying special attention to the bridging sites of large rivers, of which the best crossings, within reasonable limits of deviation, are to be selected.

The line should cross rivers at right angles and with easy curves.

3. In *chaining*, make a fresh start at every mile, not at every station.

4. Permanent and easily recognized *bench marks*, such as notches cut on large trees, rocks, &c., are to be recorded.

How the staff is held is to be clearly described and sketched.

One bench mark at least in each mile is to be made.

If the survey is near head-quarters, the permanent *station* bench mark is to be levelled over, and referred to.

Bench marks of the previous day's work should be checked before commencing day's levelling.

5. The *chief objects* along the line, such as towns, rivers, tanks, temples, isolated trees, to be included in the survey.

In the case of hills, their several peaks, spurs, and terminations of ranges should be fixed by bearings or angles.

6. The position of *building* and "*metal*" *stone* quarries to be fixed if within ½ a mile of the line; also the distance and direction of *lime*, *kunkur*, and *moorum* quarries to be given.

When further off than ½ a mile, their distance is to be ascertained, and written on the plan, mile by mile.

7. The description of *soil*, and, if possible, the *sub-soil* chained over, and the points of change of one sort of soil for another, to be noted.

8. When a *stream* is crossed, sights in detail are to be taken; the staff being held at least at the top and bottom of its banks, and at the lowest point in the bed of the stream.

9. The *nature* of the *banks*, and the strata composing the *bed* to be noted; and the depths at which solid *foundation* may be obtained, all across, to be ascertained, if necessary, by sinking trial pits, or by borings.

The level of *highest floods* to be recorded after careful enquiry from villagers, and investigation of the country. The courses of *all* streams for one hundred feet at least, to be included in the survey; but if the stream be such as would be likely to require a small bridge, it is to be surveyed for ½ a mile on either side of the line.

10. The probable *size* of the *bridge* required may be ascertained as follows:—The course of the stream is examined above and below the crossing, for a well defined section, and from a sketch of this, taped roughly, an estimate of the waterway can be formed.

11. If the bridge is likely to be of 15 feet *span*, or over, a *longitudinal section* of its bed, or of the water in its bed, for ½ a mile on either side of the crossing, and a *cross* section at each end, that is at ½ a mile up stream, and ½ a mile down stream, to be taken.

These sections should give the highest, as well as ordinary, flood levels—the sections being carried out beyond reach of the floods; and from them will be obtained the area of flood section, the wetted border and the fall per mile, in detail.

When a river branches, or divides within the half mile, a section across all its branches must be given; and in such case, other sections at same intermediate points showing the river undivided, should be taken.

12. The sizes of drains and *bridges*, if any, on the same stream, either above or below the line, should be given.

13. In case of the bridge being a large one, that is of 100 running feet of waterway, or of a single span of 40 feet, or over, the above-

mentioned survey and section should be extended to 1 mile on either side, and a *special memorandum* should be drawn up pointing out any difficulties or facilities of construction; with the distance at which good stone, lime, sand, wood, &c., can be procured.

14. *Cross sections* of the country to be taken—above four in the mile—at right angles to the line, and extending to between 150 to 300 feet, according to circumstances, but always beyond water line of flooded lands on either side of the line.

The middle sight of these sections must be one of the staff points of the section of the main line.

These sections should show the general side inclination of the country, and the level of any floods on land by the side of the line. The staff points on these sections need seldom be closer than 100 feet apart.

15. But when the side slope of the country is steeper than 4°—about 1 in 15—these cross sections should be taken at about 100 feet apart, and they should, when plotted to a large scale, be used to calculate the earthwork.

16. The several sections should show, without any unnecessary detail, all changes of surface, the heights of floods on the lands, &c. It will facilitate the calculations of the earthwork, if the distances and sights are taken, as far as possible, at even hundreds; and it is usually possible to take them so without sacrificing accuracy to any appreciable extent. This does not refer to sections of nullas, where the detail should of course be greater.

PLANS AND OFFICE WORK.

17. The *datum* is to be selected a sufficient number of feet below the station, or other *permanent* and *defined* bench mark.

18. The *office copy*, or rough plot, to be as far as possible on continuous paper; the plan below the section.

The cross sections of the country, above the point of section on the same sheet.

The *fair copy* to be on paper, or tracing cloth, in sheets of the size of royal paper (24″ × 19″), and containing in the sheet 1 or 2 miles according to the scale selected.

The last furlong of the previous sheet to be repeated, at the commencement of each sheet, *in outline*.

The survey line to be in red; other lines to be in black, or other appropriate colour.

19. The *scales* for *general survey plan*, *longitudinal section*, and *cross sections* of the *country* to be 600 feet to the inch for the horizontal, and 40 feet for the vertical.

In special cases, as in intricate ground, or where more details are required, the scales may be 300 feet and 20 feet (respectively horizontal and vertical) to the inch.

The *cross sections* of *streams*, mentioned in para. 11, to be 40 feet to the inch, both vertical and horizontal: but the *longitudinal section* of the *bed* may be 600 feet horizontal and 40 feet vertical.

20. The *primary datum* should, as far as practicable, be used as the datum line drawn on the sections; but when necessary, for economy of space, or for convenience, otherwise, secondary datum lines may be ruled at a given number of feet, above the assumed primary datum. This change should be noted on each sheet of the section; but *the heights written on the verticals must always be the true heights over the primary datum*, usually those of the "reduced level" column of the field book.

21. Vertical (fine) lines are to be ruled at every change of inclination of the surface; and on them is to be written, in the following order upwards:—

1*st*.—The height of natural surface of ground over datum.

2*nd*.—The height of formation over ditto.

3*rd*.—The height of filling, or depth of cutting.

The last two are usually filled in after the Engineer has ruled the formation line.

When the verticals are very close together, as is usually the case at the nullas, the drawing becomes crowded, and the heights cannot easily be entered on the verticals; it is, however, seldom *necessary* on the fair copy to give more lines than one showing the lowest point of the bed, one for the flood lines, and one where each abutment of the drain will come, and of course one at each side at the top of the nulla banks.

22. The *horizontal distances* to be written continuously, in miles and feet, from the commencement of the section; each mile being marked distinctly in Roman figures.

23. The various classes of *soil* should be shown by conventional sectional edging in colours, such as:—

Moorumy, or red soil	Burnt Sienna.
Black soil...	Indian Ink.
Rock	Indigo.

Boulders in any of these soils may be shown by hatching, or conventional etching of stones.

24. The *formation* line (the surface of road under the metalling or mooruming) to be shown by a red line.

At each change of gradient along it should be ruled *heavy* black verticals, between which should be written the rate of inclination, or grades, as, 1 in 100, &c.

25. *Embankments* may be colored yellow, green, or brown; and *cuttings* red.

Although not necessary by rule, yet it will assist the calculator to give the distances between the verticals used to estimate the contents of banks and cuttings. These intermediate distances may be written over the 3rd horizontal column of the section.

26. The *water courses* and *rivers* are to be numbered consecutively on both plan and section; and on the latter is to be written the size of the structure required, the height of formation being given on the central vertical in the bed.

27. On each sheet of the plan *north point* is to be put.

The *names* of villages, rivers, tanks, &c., given.

The *direction* of flow of *streams* shown by arrows.

Tracks, or other roads leading to towns not shown in the plan, to have their *destination* indicated by To—— From——

28. The *detailed cross* and *longitudinal sections of streams* mentioned in paragraphs 11 and 19, requiring bridges of 15 feet and over, may be drawn on a series of separate sheets; or, may be given on the same sheet as the design of the bridge. The latter plan is convenient when the bridges are small, or likely to be detached from the book of plans, and it has the advantage of giving all the data in collected form. These sections, cross and longitudinal, are intended to show all the data required to calculate the velocity of the river, *viz.* area, border, hydraulic mean depths, and fall per mile.

29. *Detailed cross sections of the country*, when required for the calculation of the quantities of cutting and embankment, paragraph 15, are to be plotted on separate sheets, at a scale of 40 feet to the inch horizontal and vertical; and on them are to be drawn the cross sections of the road, giving the outline of the formation catchwaters, &c.

30. Enlarged cross sections of the rivers *at the bridging sites* are to be replotted separately—if necessary, for room, on separate sheets—at a scale of 20 or 10 feet to the inch, according to scale selected for elevation of bridges, and on these sections are to be drawn, in outline, the elevations, plans, and transverse sections of the bridges, with design of centres, &c. On these sections should be shown the *ordinary* as well as the *highest*, flood lines, with the *date* of the latter if possible; the hot-weather water lines; the nature of the banks, and the strata forming the bed of the river, the borings, or trial pits, being regularly plotted on the section for this purpose. On the same sheets should also be shown:—

The mean of the three hydraulic mean depths.

The velocity of the river in feet per second, and the afflux calculated for the obstruction of the bridge. If detail sections are on the same sheet, as proposed in paragraph 28, this information should be given.

Scales should be also given on each sheet.

Details, at scales of from 10 to 5 feet to an inch, to be given, if necessary; and may be on the same, or another sheet, as found convenient.

31. The elevations and plans of drains may also be drawn at a scale of 10 feet to an inch; but if the "average plans" be used, the drawings are unnecessary.

32. *Two general maps* of the line are to be prepared :—

A sketch map (a tracing from the Trigonometrical maps), at a scale of 4 miles to the inch, of the country through which the line runs, on foolscap size, to accompany report.

An index map, on royal size, to accompany plans at a scale of 1 mile to the inch. This may be enlarged from the Revenue Survey táluka maps at 2 miles to the inch; but a simple tracing from them would usually suffice.

This map should show all towns, within 3 miles of the line of road, and the direction of the chief ones beyond this distance, say up to 15 miles.

This map may be drawn on the title page, under the title, if there is room.

33. The title page should give the designation of the road; a memorandum of the letter, and estimate accompanying it; the several scales; and a "reference," showing what the various colours and lines represent in the body of the plans.

34. A sheet of *general cross sections* showing in detail the method of forming of the road—on level, in banks, in cuttings, on side long ground, and in ghâts—should accompany. The scale of these sections to be at least 10 feet to the inch.

35. If possible a road should be surveyed and plotted from east to west, or from south to north, in order that the north may, as far as possible, be in the conventional position.

XII.—TABLES.

	Page
I.—Scantlings of Teak Joists	421
II.— Do. do. do.	421
III.— Do. do. Girders	422
IV.— Do. do. do.	422
V.—Door Frames	423
VI.—Doors Panelled	424
VII.— Do. partly Panelled and partly Glazed	425
VIII.— Do. Batten	426
IX.— Do. Framed and Braced	427
X.— Do. Framed Batten	428
XI.—Window Frames	429
XII.— Do. do. (Iron Barred)	429
XIII.—Windows, Glazed	430
XIV.— Do. Venetianed	432
XV.— Do. Batten	433
XVI.— Do. Iron Barred with Glazed Shutters	434
XVII.—Scantlings of Trusses	435
XVIII.— Do. Principals, Purlins, Rafters, &c.	436
XIX.— Do. Double-tiled Verandah Roofs	437
XX.— Do. Single do. do. do.	438
XXI.— Do. of Trusses for C. I. Roofs	439
XXII.—Straps and Bolts	439
XXIII.—Timber-topped Culverts	440
XXIV.—Iron-work for do.	443
XXV.—Burke's Tables of Task Work	445
XXVI.—Taskwork in different soils	448
XXVII.—Conveyance by Coolies	450
XXVIII.— Do. by Carts	451

Tables for the Calculation of Earthwork.

First Series.

XXIX.—Base 18, Slope $\frac{1}{2}$ to 1	455
XXX.— „ 18 „ 1 to 1	456
XXXI.— „ 18 „ $1\frac{1}{2}$ to 1	457
XXXII.— „ 18 „ 2 to 1	458
XXXIII.— „ 20 „ $\frac{1}{2}$ to 1	459
XXXIV.— „ 20 „ 1 to 1	460
XXXV.— „ 20 „ $1\frac{1}{2}$ to 1	461
XXXVI.— „ 20 „ 2 to 1	462
XXXVII.— „ 22 „ $\frac{1}{2}$ to 1	463
XXXVIII.— „ 22 „ 1 to 1	464
XXXIX.— „ 22 „ $1\frac{1}{2}$ to 1	465
XL.— „ 22 „ 2 to 1	466
XLI.— „ 24 „ $\frac{1}{2}$ to 1	467
XLII.— „ 24 „ 1 to 1	468
XLIII.— „ 24 „ $1\frac{1}{2}$ to 1	469
XLIV.— „ 24 „ 2 to 1	470

First Series—continued.

	Page.
XLV.—Base 26, Slope ½ to 1	471
XLVI.— „ 26 „ 1 to 1	472
XLVII.— „ 26 „ 1½ to 1	473
XLVIII.— „ 26 „ 2 to 1	474

Second Series.

XLIX.—Base 1, Slope ½ to 1	475
L.— „ „ „	476
LI.— „ „ „	477
LII.— „ „ „	478
LIII.— „ „ „	479
LIV.— „ „ „	480
LV.— „ „ „	481
LVI.— „ „ „	482
LVII.— „ „ 1 to 1	483
LVIII.— „ „ „	484
LIX.— „ „ „	485
LX.— „ „ „	486
LXI.— „ „ „	487
LXII.— „ „ „	488
LXIII.— „ „ „	489
LXIV.— „ „ „	490
LXV.— „ „ 1½ to 1	491
LXVI.— „ „ „	492
LXVII.— „ „ „	493
LXVIII.— „ „ „	494
LXIX.— „ „ „	495
LXX.— „ „ „	496
LXXI.— „ „ „	497
LXXII.— „ „ „	498
LXXIII.— „ „ 2 to 1	499
LXXIV.— „ „ „	500
LXXV.— „ „ „	501
LXXVI.— „ „ „	502
LXXVII.— „ „ „	503
LXXVIII.— „ „ „	504
LXXIX.— „ „ „	505
LXXX.— „ „ „	506

Tables for calculating Areas of Arch-rings, Segments, &c.

LXXXI.—General Table	507
LXXXII.—Rise ½ and ⅓	508
LXXXIII.—Rise ¼ and ⅕	509
LXXXIV.—Rise ⅙ and ⅐	510

TABLE I.—Scantlings of Teak Joists at 12 inches central distance apart.

Length of Bearing in Feet.	Load 1¼ Cwt. per Square Foot.									
	Scantlings in Inches.									
	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.
VI.	2	4½	2¼	4¼	2½	4	2¾	4	3	3¾
VIII.	2	6	2¼	5¾	2½	5½	2¾	5¼	3	5
X.	2	7¼	2¼	7	2½	6¾	2¾	6½	3	6¼
XII.	2	8¾	2¼	8½	2½	8	2¾	7¾	3	7½
XIV.	2	10¼	2¼	10	2½	9½	2¾	9¼	3	9
XVI.	2	11¾	2¼	11½	2½	11	2¾	10½	3	10¼
XVIII	2	13	2¼	12¾	2½	12¼	2¾	11¾	3	11½
XX.	2	14½	2¼	14	2½	13½	2¾	13	3	12¾

TABLE II.—Scantlings of Teak Joists at 12 inches central distance apart.

Length of Bearing in Feet.	Load 1½ Cwt. per Square Foot.									
	Scantlings in Inches.									
	B.	D.	B.	D.	B.	D.	B.	D.	B.	D.
VI.	2	4¾	2¼	4½	2½	4¼	2¾	4¼	3	4
VIII.	2	6¼	2¼	6	2½	5¾	2¾	5½	3	5¼
X.	2	7¾	2¼	7½	2½	7¼	2¾	7	3	6¾
XII.	2	9½	2¼	9	2½	8½	2¾	8¼	3	8
XIV.	2	11	2¼	10½	2½	10	2¾	9¾	3	9½
XVI.	2	12½	2¼	12	2½	11½	2¾	11	3	10¾
XVIII	2	14	2¼	13½	2½	13	2¾	12½	3	12¼
XX.	2	15½	2¼	15	2½	14½	2¾	14	3	13½

Note.—Tables I to IV have been calculated from the formula for Deflection

$$D = \frac{5}{8} \times \frac{1}{16} \times \frac{L^3 \times W}{E \times bd^3}$$

in which $D = \frac{L}{40}$ and E is a constant for resistance of teak to deflection for L in feet, or Modulus of Elasticity ÷ 4 × 1728. This last has been taken as 281 in Tables I and II, and 250 in Tables III and IV.

TABLE III.—Scantlings of Teak Girders.

SPANS IN FEET.	Load 1¼ Cwt. per Square Foot. Distance from centre to centre of Girders in feet.											
	5		6		7		8		9		10	
	B″	D″	B″	D″	B″	D″	B″	D″	B″	D″	B″	D″
X	5½	9¼	5¾	9¾	5¾	10¼	6	10½	6¼	10¾	6½	11
XII	6¼	10¾	6½	11¼	6¾	11¾	7	12	7¼	12½	7¼	12¾
XIV	7	12	7¼	12½	7½	13	7¾	13½	8	14	8¼	14¼
XVI	7¾	13¼	8	14	8¼	14½	8½	15	8¾	15¼	9	15¾
XVIII	8¼	14½	8¾	15¼	9	15¾	9½	16¼	9¾	16¾	10	17½
XX	9	15¾	9½	16½	9¾	17	10¼	17¾	10½	18¼	10¾	18¾
XXII	9¾	16¾	10¼	17¾	10½	18¼	11	19	11¼	19½	11½	20
XXIV	10½	18	11	18¾	11¼	19½	11¾	20¼	12	20¾	12¼	21½

TABLE IV.—Scantlings of Teak Girders.

S PANS IN FEET.	Load 1½ Cwt. per Square Foot. Distance from centre to centre of Girders in feet.											
	5		6		7		8		9		10	
	B″	D″	B″	D″	B″	D″	B″	D″	B″	D″	B″	D″
X	5¾	9¾	6	10¼	6¼	10½	6¼	11	6½	11¼	6¾	11½
XII	6½	11¼	6¾	11¾	7	12¼	7¼	12½	7½	13	7¾	13¼
XIV	7¼	12½	7½	13¼	8	13¾	8¼	14¼	8½	14½	8½	15
XVI	8	14	8½	14½	8¾	15	9	15½	9¼	16	9½	16½
XVIII	8¾	15¼	9¼	16	9½	16½	9¾	17	10¼	17½	10½	18
XX	9½	16½	10	17¼	10¼	17¾	10¾	18½	11	19	11¼	19½
XXII	10¼	17¾	10¾	18½	11	19¼	11½	19¾	11¾	20½	12	21
XXIV	10¾	18¾	11½	19¾	11¾	20½	12¼	21¼	12½	21¾	13	22½

Note.—The above tables have been calculated by the formula for Deflection ($\frac{1}{10}$ inch per foot) with B : D : : 1 : $\sqrt{3}$.

Note.—To extend the use of Tables I to IV it may be noted that if the load per square foot be increased or decreased, or the central distance apart, then the breadth should be increased or decreased in the same proportion.

For example in Table II, if the joists be placed at 15 inches apart in a 20 feet bearing, the breadth of the jost should be increased from 2 to 2½ inches for equal strength.

TABLE V.—Door, Frames.

Size of Door.	Scantling of Door Frames. Description.	Number.	Length in feet.	Breadth in Inches.	Thickness in Inches.	Cubic Contents of Frames.	Remarks.
4½′ × 7½′	Posts	2	8·16	5	4	3·146	*Note.*—These frames are suitable for the Doors detailed in Tables Nos. VI to X. The "breadth" or greater dimension of the frame is in the plane of the Door. *N.B.*—A small allowance is made for waste in the above quantities.
	Head	1	6·33	5	4	
	Sill	1	6·33	3	4	·527
					Total Cub. ft. ...	3·673	
4′ × 7′	Posts	2	7·58	4½	4	2·614	
	Head	1	5·75	4½	4		
	Sill	1	5·75	3	4	·479	
					Total Cub. ft. ...	3·093	
3½′ × 7′	Posts	2	7·58	4½	3¾	2·392	
	Head	1	5·25	4½	3¾		
	Sill	1	5·25	3	3¾	·410	
					Total Cub. ft. ...	2·802	
3½′ × 6½′	Posts	2	7·08	4½	3½	2·123	
	Head	1	5·25	4½	3½		
	Sill	1	5·25	3	3½	·382	
					Total Cub. ft. ...	2·505	
3′ × 6½′	Posts	2	7·08	4½	3½	1·948	
	Head	1	4·7	4½	3½		
	Sill	1	4·7	3	3½	·342	
					Total Cub. ft. ...	2·290	
3′ × 6′	Posts	2	6·58	4	3½	1·716	
	Head	1	4·5	4	3½		
	Sill	1	4·5	3	3½	·328	
					Total Cub. ft. ...	2·044	
2½′ × 6′	Posts	2	6·58	4	3½	1·668	
	Head	1	4	4	3½		
	Sill	1	4	3	3½	·291	
					Total Cub. ft. ...	1·959	

TABLE VI.—Doors, Panelled.

Size of Door.	Description.	Scantling of Door. Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Strong Butt Hinges.	Fastenings. Tower Bolt 12″	Do. 10″	Do. 8″	Do. 7″	Rim Locks.	Hooks and Eyes 10″
								No.	No.	No.	No.	No.	No.
4½′×7½′	Stiles	4	7′ 6″	4″	1½″	1·250	3 pairs 5″	1	..	1	..	1	2
	Lock rail	2	2′ 3½″	8″	1½″	·381							
	Top bottom and frieze rails ..	6	2′ 3½″	4″	1½″	·572							
	Panels	4	6′ 4″	11″	1¼″	2·419							
	Total Cub. ft...					4·622							
4′×7′	Stiles	4	7′ 0	3¾″	1½″	1·083	3 pairs 4½″	..	1	1	..	1	2
	Lock rail	2	2′ ½″	7¾″	1½″	·329							
	Top bottom and frieze rails ..	6	2′ ½″	3¾″	1½″	·478							
	Panels	4	6′ 0″	10″	1½″	2·083							
	Total Cub. ft....					3·983							
3½′×7′	Stiles	4	7′ 0″	3¾″	1¼″	·911	3 pairs 4″	..	1	1	..	1	2
	Lock rail	2	1′ 9½″	7¾″	1¼″	·241							
	Top bottom and frieze rails ..	6	1′ 9½″	3¾″	1¼″	·350							
	Panels	2	6′ 0″	1′ 4″	1″	1·333							
	Total Cub. ft. ..					2·835							
3½′×6½′	Stiles	4	6′ 6″	3¾″	1¼″	·846	3 pairs 4″	..	..	1	1	1	2
	Lock rail	2	1′ 9½″	7″	1¼″	·217							
	Top bottom and frieze rails ..	4	1′ 9½″	3¾″	1¼″	·233							
	Panels	2	5′ 9″	1′ 4″	1″	1·277							
	Total Cub. ft....					2·573							
3′×6½′	Stiles	4	6′ 6″	3½″	1¼″	·789	2 pairs 4½″	..	..	1	1	1	2
	Lock rails	2	1′ 6½″	7″	1¼″	·187							
	Top bottom and frieze rails ..	4	1′ 6½″	3½″	1½″	·187							
	Panels	2	5′ 9″	1′1½″	1″	1·078							
	Total Cub. ft. ..					2·241							

TABLE VII.—Doors, partly panelled and partly glazed.

Size of Door	Scantling of Door. Description.	Number.	Length. Ft.	Length. In.	Breadth. Ft.	Breadth. In.	Thickness. In.	Cubic Contents of Door.	Glass. No. of Panes.	Glass. Dimensions. In.	Strong butt hinges. No.	Fastenings. Tower bolts 12″ No.	Do. do. 10″ No.	Do. do. 8″ No.	Do. do. 7″ No.	Rim Locks. No.	Hooks and Eyes 10″ No.
$4\frac{1}{2}' \times 7\frac{1}{2}'$	Stiles	4	7	6	0	4	$1\frac{1}{2}$	1·250	16	$11\frac{1}{2} \times 9\frac{3}{8}$	3 prs 5″	1	..	1	..	1	2
	Lock rails	2	2	$3\frac{1}{2}$	0	8	$1\frac{1}{2}$	·381									
	Top and bottom rails	4	2	$3\frac{1}{2}$	0	4	$1\frac{1}{2}$	·381									
	Panels	4	2	6	0	11	$1\frac{1}{4}$	·954									
	Sash bars, Vertical	2	4	0	0	1	$1\frac{1}{2}$	·083									
	Do. do. Horizontal	6	1	9	0	1	$1\frac{1}{2}$	·109									
	Total Cub. ft.							3·158									
4′×7′	Stiles	4	7	0	0	$3\frac{1}{2}$	$1\frac{1}{2}$	1·093	16	$10\frac{1}{2} \times 8\frac{3}{8}$	3 prs $4\frac{1}{2}$″	..	1	1	..	1	2
	Lock rails	2	2	$\frac{1}{2}$	0	$7\frac{3}{4}$	$1\frac{1}{2}$	·329									
	Top and bottom rails	4	2	$\frac{1}{2}$	0	$3\frac{1}{4}$	$1\frac{1}{2}$	·320									
	Panels	4	2	4	0	10	$1\frac{1}{4}$	·810									
	Sash bars, Vertical	2	3	9	0	1	$1\frac{1}{2}$	·078									
	Do. Horizontal	6	1	7	0	1	$1\frac{1}{2}$	·098									
	Total Cub. ft.							2·728									
$3\frac{1}{2}' \times 7'$	Stiles	4	7	0	0	$3\frac{1}{2}$	$1\frac{1}{2}$	·350	16	$10\frac{1}{2} \times 7\frac{1}{8}$	3 prs 4″	..	1	1	..	1	2
	Lock rails	2	1	$9\frac{1}{2}$	0	$7\frac{1}{4}$	$1\frac{1}{4}$	·241									
	Top and bottom rails	4	1	$9\frac{1}{2}$	0	$3\frac{1}{2}$	$1\frac{1}{2}$	·217									
	Panels	2	2	$4\frac{1}{2}$	1	4	1	·527									
	Sash bars, Vertical	2	3	9	0	1	$1\frac{1}{4}$	·065									
	Do. Horizontal	6	1	4	0	1	$1\frac{1}{4}$	·069									
	Total Cub. ft.							1·969									
$3\frac{1}{2}' \times 6\frac{1}{2}'$	Stiles	4	6	6	0	$3\frac{1}{2}$	$1\frac{1}{2}$	·789	16	$9\frac{1}{2} \times 7\frac{1}{8}$	3 prs 4″	..	..	1	1	1	2
	Lock rails	2	1	$9\frac{1}{2}$	0	7	$1\frac{1}{4}$	·217									
	Top and bottom rails	4	1	$9\frac{1}{2}$	0	$3\frac{1}{2}$	$1\frac{1}{4}$	·217									
	Panels	2	2	4	1	4	1	·518									
	Sash bars, Vertical	2	3	4	0	1	$1\frac{1}{4}$	·057									
	Do. Horizontal	6	1	4	0	1	$1\frac{1}{4}$	·069									
	Total Cub. ft.							1·867									
3′×6½′	Stiles	4	6	6	0	$3\frac{1}{2}$	$1\frac{1}{2}$	·733	16	$9\frac{1}{2} \times 5\frac{7}{8}$	2 prs $4\frac{1}{2}$″	..	..	1	1	1	2
	Lock rails	2	1	$6\frac{1}{2}$	0	7	$1\frac{1}{4}$	·187									
	Top and bottom rails	4	1	$6\frac{1}{2}$	0	$3\frac{1}{2}$	$1\frac{1}{4}$	·174									
	Panels	2	2	$4\frac{1}{2}$	1	2	1	·461									
	Sash bars, Vertical	2	3	4	0	1	$1\frac{1}{4}$	·057									
	Do. Horizontal	6	1	2	0	1	$1\frac{1}{4}$	·060									
	Total Cub. ft.							1·672									

TABLE VIII.—Doors, batten.

Size of Door.	Scantling of Door. Description.	Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Strong Butt Hinges.	Fastenings. Tower Bolt 12″	Do. 10″	Do. 8″	Do. 7″	Handles.	Hooks and Eyes 10″
			Ft. In.	In.	In.			No.	No.	No.	No.	No.	No.
4½′×7½′	Planks	10	7 6	6¼	1¼	4·069	3 pairs 5″	1	1	..	..	1	2
	Battens, Vertical	1	7 6	3	1½	·234							
	Do. Horizontal	3	4 3	3	1½	·398							
	Do. Diagonal	4	4 0	3	1½	·500							
	Total Cubic ft.					5·201							
4′×7′	Planks	8	7 0	6¾	1½	3·281	3 pairs 4½″	..	1	1	..	1	2
	Battens, Vertical	1	7 0	3	1½	·218							
	Do. Horizontal	4	3 9	3	1½	·468							
	Total Cubic ft.					3·967							
3½′×7	Planks	8	7 0	6	1½	2·916	3 pairs 4½″	..	1	1	..	1	2
	Battens, Vertical	1	7 0	3	1½	·218							
	Do. Horizontal	4	3 3	3	1½	·406							
	Total Cubic ft.					3·540							
3½′×6½′	Planks	8	6 6	6	1½	2·708	3 pairs 4″	..	..	1	1	1	2
	Battens, Vertical	1	6 6	3	1½	·203							
	Do. Horizontal	3	3 3	3	1½	·304							
	Total Cubic ft.					3·215							
3′×6½′	Planks	8	6 6	5½	1	1·895	2 pairs 4½″	..	..	1	1	1	2
	Battens, Vertical	1	6 6	3	1½	·169							
	Do. Horizontal	3	2 9	3	1½	·214							
	Total Cubic ft.					2·278							
3′×6′	Planks	8	6 0	5½	1	1·750	2 pairs 4″	..	..	1	1	1	2
	Battens, Vertical	1	6 0	3	1½	·156							
	Do. Horizontal	3	2 9	3	1½	·214							
	Total Cubic ft.					2·110							
2½′×6*	Planks	6	6 0	5¾	1	1·437	1½ pairs 4″	..	..	1	1	1	1
	Do. Horizontal	3	2 6	3	1½	·195							
	Total Cubic ft.					1·632							

* To open in one leaf.

TABLE IX —Doors, Framed and Braced.

Size of Door.	Scantling of Door. Description.	Number.	Length.	Breadth.	Thickness.	Cubic contents.	Strong Butt Hinges.	Fastenings. Tower Bolts 12″.	Do. 10″	Do. 8″	Do. 7″	Aldrop Bolt.	Hooks & Eyes 12″
			Ft. In.	In.	In.	C.F.		No.	No.	No.	No.	No.	No.
5′ × 8′	Stiles	4	8 0	4½	2	2·00	3 pairs 5″	2	1	..	..	1	2
	Top rails	2	2 6	4½	2	·31							
	Centre and bottom do.	4	2 6	7	1⅛	·55							
	Braces	2	4 6	4	1⅛	·32							
	Do.	2	4 0	4½	1⅛	·28							
	Battens	10	7 9	4½	⅝	2·12							
	Total Cub. ft. ..					5·58							
4½′ × 7½′	Stiles	4	7 6	4½	1¾	1·64	3 pairs 5″	2	1	..	..	1	2
	Top rails	2	2 3	4½	1¾	·25							
	Centre and bottom do.	4	2 3	7	1	·44							
	Braces	2	4 3	4½	1	·27							
	Do.	2	3 9	4½	1	·23							
	Battens	8	7 3	4¾	¾	1·43							
	Total Cub. ft. ..					4·26							
4′ × 7′	Stiles	4	7 0	4½	1⅝	1·42	3 pairs 4″	..	2	1	..	1	2
	Top rails	2	2 0	4½	1⅝	·20							
	Centre and bottom do.	4	2 0	7	1	·39							
	Braces	2	4 0	4½	1	·25							
	Do.	2	3 0	4½	1	·10							
	Battens	8	6 9	4½	⅝	1·05							
	Total Cub. ft. ..					3·41							
3½′ × 7′	Stiles	4	7 0	4½	1½	1·31	3 pairs 4″	..	2	1	..	1	2
	Top rails	2	1 9	4½	1½	·16							
	Centre and bottom do.	4	1 9	7	⅝	·30							
	Braces	2	4 0	4½	⅝	·22							
	Do.	2	3 0	4½	⅝	·16							
	Battens	8	6 9	4	⅝	·94							
	Total Cub. ft. ..					3·09							
3½′ × 6½′	Stiles	4	6 6	4½	1½	1·22	3 pairs 4″	..	2	1	..	1	2
	Top rails	2	1 9	4½	1½	·16							
	Centre and bottom do.	4	1 9	7	⅝	·30							
	Braces	2	3 6	4½	⅝	·19							
	Do.	2	3 0	4½	⅝	·16							
	Battens	8	6 3	4	⅝	·87							
	Total Cub. ft. ..					2·90							
3′ × 6½′	Stiles	4	6 6	4½	1½	1·22	3 pairs 3½″	..	..	2	1	1	2
	Top rails	2	1 6	4½	1½	·14							
	Centre and bottom do.	4	1 6	6	⅝	·22							
	Braces	2	3 0	4½	⅝	·16							
	Do.	2	3 0	4½	⅝	·16							
	Battens	6	6 3	4½	⅝	·73							
	Total Cub. ft. ..					2·63							

TABLE X.—Doors, Framed batten.

Size of Door.	Description.	Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Strong Butt Hinges.	Fastenings. Tower Bolt 12″.	Do. do. 10″.	Do. do. 8″.	Do. do. 7″.	Rim Lock.	Hooks and Eyes 10″
			Ft. In.	In.	In.			No.	No.	No.	No.	No.	No.
4½′×7½′	Stiles	4	7 6	4	1½	1·250	3 pairs 5″.	1	...	1	...	1	2
	Lock rails	2	2 3½	8	1½	·381							
	Top, bottom and frieze rails.	6	2 3½	4	1½	·572							
	Battens	10	6 4	4¾	1	2·089							
	Total Cubic feet ...					4·292							
4′×7′	Stiles	4	7 0	3¾	1½	1·093	3 pairs 4½″.	...	1	1	...	1	2
	Lock rails	2	2 0½	7¾	1½	·329							
	Top, bottom and frieze rails.	6	2 0½	3¾	1½	·480							
	Battens	10	6 0	4¼	1	1·770							
	Total Cubic feet ...					3·672							
3½′×7′	Stiles	4	7 0	3¾	1¼	·911	3 pairs 4″.	...	1	1	...	1	2
	Lock rails	2	1 9½	7¾	1¼	·241							
	Top, bottom and frieze rails.	6	1 9½	3¾	1¼	·350							
	Battens	8	6 0	4¼	⅜	1·062							
	Total Cubic feet ...					2·564							
3½′×6½′	Stiles	4	6 6	3¾	1¼	·846	3 pairs 4″.	...	...	1	1	1	2
	Lock rails	2	1 9½	7	1¼	·217							
	Top, bottom and frieze rails.	4	1 9½	3¾	1¼	·233							
	Battens	8	5 9	4¼	⅜	1·018							
	Total Cubic feet ...					2·314							
3′×6½′	Stiles...	4	6 6	3½	1¼	·789	2 pairs 4½″.	...	...	1	1	1	2
	Lock rails	2	1 6½	7	1¼	·187							
	Top, bottom and frieze rails.	4	1 6½	3½	1¼	·187							
	Battens	6	5 9	4¾	⅜	·853							
	Total Cubic feet ...					2·016							

N.B.—The only difference between these doors and panelled doors is the substitution of narrow battens for panels. The battens are flush with the framing on the inside and sunk ½″ on the outside.

TABLE XI.—Window Frames.

Size of Window.	Scantling of Window Frames. Description.	Number.	Length in Feet.	Breadth in Inches.	Thickness in Inches.	Cubic Contents of Frames.	Remarks.
4′×5′	Posts	2	5·66	4	3½	2·203	Note.—These frames are suitable for the windows detailed in Tables Nos. XIII. to XV. The "breadth" or greater dimension is in the plane of the window. *N. B.*—A small allowance is made for waste in the above quantities.
	Head and Sill	2	5·66				
3½′×5′	Posts	2	5·66	4	3½	2·106	
	Head and Sill	2	5·16				
3½×4½′	Posts	2	5·16	4	3½	2·009	
	Head and Sill	2	5·16				
3′×4½′	Posts	2	5·08	3½	3¼	1·513	
	Head and Sill	2	4·50				
3′×4′	Posts	2	4·58	3½	3	1·324	
	Head and Sill	2	4·50				
2½′×3½′	Posts	2	4·	3	3	·979	
	Head and Sill	2	3·83				
2′×3′	Posts	2	3·50	3	3	·854	
	Head and Sill	2	3·33				
1½′×2½′	Posts	2	3·	3	2½	·607	
	Head and Sill	2	2·83				
5′×3′	Posts	2	3·66	4	3½	2·009	
	Head and Sill	2	6·66				
3′×1½′	Posts	2	2·	3	3	·791	
	Head and Sill	2	4·33				
3′×1′	Posts	2	1·50	3	2½	·607	
	Head and Sill	2	4·33				

TABLE XII.—Window Frames. (Iron Barred).

Size of Window.	Scantling of Window Frames. Description.	Number.	Length in Feet.	Breadth in Inches.	Thickness in Inches.	Cubic Contents of Frames.	Remarks.
4′×5′	Posts	2	5·66	4	4½	2·833	Note.—These frames are suitable for windows iron-barred with glazed shutters. The "breadth" or less dimension is in the plane of the window. *N. B.*—A small allowance is made for waste in the above quantities.
	Head and Sill	2	5·66				
3½′×5′	Posts	2	5·66	4	4½	2·708	
	Head and Sill	2	5·16				
3½′×4½′	Posts	2	5·16	4	4½	2·439	
	Head and Sill	2	5·16				
3′×4½′	Posts	2	5·08	3½	4	1·863	
	Head and Sill	2	4·50				
3′×4′	Posts	2	4·58	3½	4	1·766	
	Head and Sill	2	4·50				
2½′×3½′	Posts	2	4·	3	3¾	1·223	
	Head and Sill	2	3·83				
2′×3′	Posts	2	3·50	3	3¾	1·067	
	Head and Sill	2	3·33				

TABLE XIII.—Windows, Glazed.

Size of Window.	Description.	Scantling of Window. Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Glass. No. of Panes.	Glass. Dimensions.	Strong Butt Hinges.	Fastenings. Tower Bolts 12″.	Do. do. 10″.	Do. do. 8″.	Do. do. 6″.	Handles.	Hooks and Eyes.
			Ft. In.	In.	In.	C. F.		In.		No.	No.	No.	No.	No.	No.
4′×5′	Stiles	4	5 0	3	1¼	·520	20	10½×9⅛	2 pairs 4″.	1	...	1	...	1	2 No. 10″.
	Rails	4	2 0½	3	1¼	·212									
	Sashbars, Vertical ...	2	4 8	1	1¼	·081									
	Do. Horizontal ...	8	1 8	1	1¼	·115									
	Total Cubic feet ...					·928									
3½′×5′	Stiles	4	5 0	3	1¼	·520	20	10½×7⅞	2 pairs 4″.	...	1	1	...	1	2 No. 10″.
	Rails	4	1 9½	3	1¼	·186									
	Sashbars, Vertical ...	2	4 8	1	1¼	·081									
	Do. Horizontal ...	8	1 5	1	1¼	·098									
	Total Cubic feet ...					·885									
3½′×4½′	Stiles	4	4 6	3	1¼	·468	20	9⅜×7⅝	2 pairs 4″.	...	1	1	...	1	2 No. 10″.
	Rails	4	1 9½	3	1¼	·186									
	Sashbars, Vertical ...	2	4 2	1	1¼	·072									
	Do. Horizontal ...	8	1 5	1	1¼	·098									
	Total Cubic feet ...					·824									
3′×4½′	Stiles	4	4 6	2¾	1¼	·429	20	9⅝×6⅜	2 pairs 3½″.	...	1	1	...	1	2 No. 10″.
	Rails	4	1 6½	2¾	1¼	·147									
	Sashbars, Vertical ...	2	4 2½	1	1¼	·073									
	Do. Horizontal ...	8	1 3	1	1¼	·086									
	Total Cubic feet ...					·735									
3′×4′	Stiles	4	4 0	2¾	1¼	·381	20	8⅛×6⅜	2 pairs 3½″.	...	...	1	1	1	2 No. 9″.
	Rails	4	1 6½	2¾	1¼	·147									
	Sashbars, Vertical ...	2	3 8½	1	1¼	·064									
	Do. Horizontal ...	8	1 3	1	1¼	·086									
	Total Cubic feet ...					·678									

TABLE XIII.—Windows, Glazed—*(continued)*.

Size of Window.	Description.	Scantling of Window. Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Glass. No. of Panes.	Dimensions.	Strong Butt Hinges.	Fastenings. Tower Bolts 12″.	Do. do. 10″.	Do. do. 8″.	Do. do. 6″.	Handles.	Hooks and Eyes.
			Ft. In.	In.	In.	C. F.		In.		No.	No.	No.	No.	No.	No.
$2\frac{1}{4}' \times 3\frac{1}{2}'$	Stiles	4	3 6	$2\frac{1}{2}$	1	·243	20	$7\frac{1}{16} \times 5\frac{1}{8}$	2 pairs 3″	...	...	...	2	1	2 No. 8″
	Rails	4	1 $3\frac{1}{2}$	$2\frac{1}{2}$	1	·089									
	Sashbars, Vertical ...	2	3 3	1	1	·045									
	Do. Horizontal ...	8	1 0	1	1	·055									
	Total Cubic feet ...					·432									
*2′ × 3′	Stiles	2	3 0	$2\frac{3}{4}$	1	·114	6	$10 \times 9\frac{5}{6}$	1 pair $3\frac{1}{2}$″	...	...	...	2	1	1 No. 8″
	Rails	2	2 $\frac{1}{2}$	$2\frac{3}{4}$	1	·077									
	Sashbars, Vertical ...	1	2 $8\frac{1}{2}$	1	1	·018									
	Do. Horizontal ...	2	1 $8\frac{1}{2}$	1	1	·023									
	Total Cubic feet ...					·232									
*$1\frac{1}{2}' \times 2\frac{1}{2}'$	Stiles	2	2 6	$2\frac{1}{2}$	1	·086	6	$8\frac{1}{6} \times 6\frac{1}{2}$	1 pair 3″	...	...	...	2	1	1 No. 8″
	Rails	2	1 $6\frac{1}{2}$	$2\frac{1}{2}$	1	·053									
	Sashbars, Vertical ...	1	2 3	1	1	·015									
	Do. Horizontal ...	2	1 3	1	1	·017									
	Total Cubic feet ...					·171									
*5′ × 3′	Stiles	2	3 0	3	$1\frac{1}{4}$	·156	15	$10\frac{1}{2} \times 9\frac{5}{8}$	1 pair 4″	...	...	2	...	1	2 No. 12″
	Rails	2	5 $\frac{1}{2}$	3	$1\frac{1}{4}$	·262									
	Sashbars, Vertical ...	4	2 8	1	$1\frac{1}{4}$	·092									
	Do. Horizontal ...	2	4 8	1	$1\frac{1}{4}$	·081									
	Total Cubic feet ...					·591									
*3′ × $1\frac{1}{2}'$	Stiles	2	1 6	$2\frac{1}{2}$	1	·052	6	$10\frac{1}{8} \times 9\frac{1}{2}$	1 pair 3″	..	...	...	2	1	2 No. 12″
	Rails	2	3 $\frac{1}{2}$	$2\frac{1}{2}$	1	·105									
	Sashbars, Vertical ...	2	1 3	1	1	·017									
	Do. Horizontal ...	1	2 9	1	1	·019									
	Total Cubic feet ...					·194									
*3′ × 1′	Stiles	2	1 0	$2\frac{1}{2}$	1	·034	3	$10\frac{1}{8} \times 7\frac{1}{2}$	1 pair 3″	...	...	...	2	1	2 No. 12″
	Rails	2	3 $\frac{1}{2}$	$2\frac{1}{2}$	1	·105									
	Sashbars, Vertical ...	2	0 9	1	1	·010									
	Total Cubic feet ...					·149									

* To open in one leaf.

TABLE XIV.—Windows, Venetianed.

Size of Window	Description.	Scantling of Window. Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Strong Butt Hinges.	Fastenings. Tower Bolts 12″.	Do. do. 10″.	Do. do. 8″.	Do. do. 6″.	Handles.	Hooks and Eyes.
			Ft. In.	In.	In.			No.	No.	No.	No.	No.	No.
4′×5′	Stiles	4	5 0	3½	1¼	·607	2 pairs 4″.	1	...	1	...	1	2 No. 10″.
	Rails	6	2 0½	3½	1¼	·372							
	Venetian blades	48	1 6½	3½	⅜	·665							
	Stanchion	4	2 1	¾	1½	·021							
	Total Cubic feet ...					1·665							
3½′×5′	Stiles	4	5 0	3½	1¼	·564	2 pairs 4″.	...	1	1	...	1	2 No. 10″.
	Rails	6	1 9½	3½	1¼	·303							
	Venetian blades	48	1 4	3½	⅜	·583							
	Stanchion	4	2 1	¾	½	·021							
	Total Cubic feet ...					1·471							
3½′×4½′	Stiles	4	4 6	3½	1¼	·507	2 pairs 4″.	...	1	1	...	1	2 No. 10″.
	Rails	6	1 9½	3½	1¼	·303							
	Venetian blades	40	1 4	3½	⅜	·486							
	Stanchion	4	1 11	¾	½	·020							
	Total Cubic feet ...					1·316							
3′×4½′	Stiles	4	4 6	3	1¼	·468	2 pairs 3½″.	...	1	1	...	1	2 No. 10″.
	Rails	6	1 6½	3	1¼	·240							
	Venetian blades	40	1 1½	3½	⅜	·402							
	Stanchion	4	1 11	¾	½	·020							
	Total Cubic feet ...					1·130							
3′×4′	Stiles	4	4 0	3	1¼	·416	2 pairs 3½″.	...	...	1	1	1	2 No. 9″.
	Rails	6	1 6½	3	1¼	·240							
	Venetian blades	36	1 1¼	3½	⅜	·362							
	Stanchion	4	1 8	0¾	½	·017							
	Total Cubic feet ...					1·035							

TABLE XV.—Windows, batten

Size of Window.	Description.	Scantling of Window. Number.	Length.	Breadth.	Thickness.	Cubic Contents.	Strong Butt Hinges.	Fastenings. Tower Bolts 12″.	Do. 10″.	Do. 8″.	Do. 6″.	Handles.	Hooks and Eyes.
			Ft. In.	In.	In.			No.	No.	No.	No.	No.	
4′×5′	Planks	8	5 0	6¾	1¼	2·343	2 pairs 5″	1	...	1	...	1	2 No. 10″.
	Battens, Vertical	1	5 0	3	1¼	·130							
	Do. Horizontal ...	3	3 9	3	1¼	·292							
	Total Cubic feet ...					2·765							
3½′×5′	Planks	8	5 0	6	1¼	2·083	2 pairs 5″	...	1	1	...	1	2 No. 10″.
	Battens, Vertical	1	5 0	3	1¼	·130							
	Do. Horizontal ...	3	3 3	3	1¼	·253							
	Total Cubic feet. ...					2·466							
3½′×4½′	Planks	8	4 6	6	1	1·500	2 pairs 4½″	...	1	1	...	1	2 No. 10″.
	Battens, Vertical	1	4 6	3	1	·093							
	Do. Horizontal ...	3	3 3	3	1	·203							
	Total Cubic feet ...					1·796							
3′×4½′	Planks	8	4 6	5½	1	1·312	2 pairs 4½″	...	1	1	...	1	2 No. 10″.
	Battens, Vertical	1	4 6	3	1	·093							
	Do. Horizontal ...	2	2 9	3	1	·171							
	Total Cubic feet ...					1·576							
3′×4′	Planks	8	4 0	5¼	1	1·166	2 pairs 4″	...	...	1	1	1	2 No. 9″.
	Battens, Vertical	1	4 0	2¾	1	·076							
	Do. Horizontal ...	2	2 9	2¾	1	·105							
	Total Cubic feet ..					1·347							
2½′×3½′	Planks	6	3 6	5½	1	·838	2 pairs 3½″	...	...	...	2	1	2 No. 8″.
	Battens, Vertical	1	3 6	2½	1	·060							
	Do. Horizontal ...	2	2 3	2½	1	·078							
	Total Cubic feet ...					·976							
*2′×3′	Planks	4	3 0	6½	1	·541	1 pair 4″	...	...	...	2	1	1 No. 8″.
	Battens, Horizontal ...	2	2 0	2½	1	·069							
	Total Cubic feet ...					·610							
*1½′×2½′	Planks	4	2 6	5	1	·347	1 pair 3½″	...	...	...	2	1	1 No. 8″.
	Battens, Horizontal ...	2	1 6	2½	1	·052							
	Total Cubic feet ...					·399							

* To open in one leaf.

TABLE XVI.—Windows iron barred, with glazed shutters.

Size of Window.	Iron Works. Description.	Number.	Length. Ft.	Length. In.	Breadth. In.	Thickness. In.	Cubic Contents.	Weight at 486 lbs. per c. ft.
4′×5′	Vertical bars	9	5	2	1	1	·322	
	Central horizontal bars	1	4	2	2½	¼	·018	
	Do. to receive ends of Vertical bars.	2	4	0	2½	⅛	·017	
	Total Cubic feet				...	...	·357	
	Total lbs.				...	...	...	173·5
3½′×5′	Vertical bars	8	5	2	1	1	·287	
	Central horizontal bars	1	3	8	2½	¼	·015	
	Do. to receive ends of Vertical bars.	2	3	6	2½	⅛	·015	
	Total Cubic feet				...	...	·317	
	Total lbs.				...	...	...	154
3½′×4½′	Vertical bars	8	4	8	⅞	⅞	·198	
	Central horizontal bars	1	3	8	2¼	¼	·014	
	Do. to receive ends of Vertical bars.	2	3	6	2¼	⅛	·013	
	Total Cubic feet				...	...	·225	
	Total lbs.				...	...	...	109·35
3′×4½′	Vertical bars	7	4	8	¾	¾	·127	
	Central horizontal bars	1	3	2	2	¼	·011	
	Do. to receive ends of Vertical bars.	2	3	0	2	⅛	·010	
	Total Cubic feet				...	...	·148	
	Total lbs.				...	...	...	71·92
3′×4′	Vertical bars	7	4	2	¾	¾	·113	
	Central horizontal bars	1	3	2	2	¼	·011	
	Do. to receive ends of Vertical bars.	2	3	0	2	⅛	·010	
	Total Cubic feet				...	...	·134	
	Total lbs.				...	...	...	65·12
2½′×3½′	Vertical bars	6	3	8	¾	¾	·085	
	Central horizontal bars	1	2	8	2	¼	·009	
	Do. to receive ends of Vertical bars.	2	2	6	2	⅛	008	
	Total Cubic feet				...	...	·102	
	Total lbs.				...	...	...	49·57
2′×3′	Vertical bars	5	3	2	¾	¾	·061	
	Bars to receive ends of Vertical bars	2	2	0	2	⅛	·006	
	Total Cubic feet				...	...	·067	
	Total lbs.				...	...	...	32·56

TABLE XVII.—Scantlings of Teakwood Trusses 10 ft. apart for Double Tiled Roofs.

Spans.	Tie Beam.				Principals.				King Post.				Struts.				Straining Beam.				Straining Sill.				Contents of Truss.
	Length'.	Breadth".	Depth".	Contents.	Length'.	Breadth".	Depth".	Contents of two.	Length'.	Breadth".	Depth".	Contents.	Length'.	Breadth".	Depth".	Contents of two.	Length'.	Breadth".	Depth".	Contents.	Length'.	Breadth".	Depth".	Contents.	
				C. F.				C. F.				C. F.				C. F.				C.F.				C.F.	C. F.
XII ..	15	3	3	·93	7¾	3	5	1·61	4½	3	6	·56	3½	3	2½	·36	...	...	...	...	...	...	...	...	3·46
XIV ..	17	3	3	1·06	9	3	5¾	2·15	5¼	3	6	·65	4¼	3	2½	·44	...	...	...	...	...	...	...	...	4·30
XVI ...	19	3	3½	1·38	10	3	6½	2·70	5¾	3	6	·71	4¾	3	2½	·49	...	...	...	...	...	...	...	...	5·28
XVIII ...	21	3¼	3¾	1·78	11½	3¼	6¾	3·50	6½	3¼	6	·88	5¼	3¼	2¾	·65	...	...	...	...	..	...	...	...	6·81
XX ..	23	3½	4	2·23	12½	3½	6¾	4·10	7	3½	6	1·02	6	3½	3	·87	...	...	...	...	...	...	...	...	8·22
XXII ...	25	3¾	4¼	2·75	14	3¾	7	5·10	7½	3¾	6	1·17	6½	3¾	3¼	1·10	...	...	...	...	...	...	...	...	10·12
												Queen Post Truss.													
	No. 2																								
XXIV ...	14¼	4	4½	3·56	9¾	4	7¼	3·92	5	4	6	1·66	5	3	2½	·52	8¾	4	6	1·45	8¾	4	3	·72	11·83
XXVI ..	15¼	4	4½	3·81	10½	4	7¾	4·52	5¼	4	6	1·75	5¼	3¼	2¾	·65	9¼	4	6	1·54	9¼	4	3	·77	13·04
XXVIII ...	16¼	4¼	4¾	4·55	11¼	4¼	8	5·31	5¾	4¼	6	2·03	5¾	3½	3	·83	10	4¼	6	1·77	10	4¼	3	·88	15·37
XXX ..	17¼	4½	5	5·39	12	4½	8	6·00	6	4½	6	2·25	6	3¾	3¼	1·01	10¾	4½	6	2·01	10¾	4½	3	1·00	17·66

Note.—These dimensions are for a roof weighing 27 lbs. per square foot with 40 lbs. more allowed for wind pressure. For Purlins, Rafters, Ridges, &c., see Table XVIII. The tie beams of queen-post trusses should be scarfed under one of the queen-posts, and not in the centre of the beam as shown above. (See Plate No. XXI-A.)

TABLE XVIII.—Scantlings of Principals, Purlins, Rafters, Ridges, &c., for Double Tiled Roofs.

Spans.	Principals. Trusses, 8 feet apart. B″	D″	Principals. Trusses, 10 feet apart. B″	D″	Purlins. Trusses, 8 feet apart. B″	D″	Purlins. Trusses, 10 feet apart. B″	D″	Common Rafters. At 18 inches central distance. B″	D″	At 15 inches central distance. B″	D″	Ridges. Trusses, 8 feet apart. B″	D″	Ridges. Trusses, 10 feet apart. B″	D″	Hip Rafters. Length′.	Breadth″.	Depth″.	Contents C. F.	Jack Rafters. Length′.	Breadth″.	Depth″.	Contents C. F.	Cut Teak Battens.	Wall Plates. Under Trusses.	Under Purlins or Ridges on Partition Walls.	Under Hips.	Eave Plate.	Eave Board.
XII...	3	4	3	5	4	5¾	4¾	6¾	2	3	1¾	2½	2½	6¼	2½	7½	14	3	5¼	1·53	...	...	...	...	2″ × ½ in. — 4 in. central distance = 2·08 c. ft. per square + 5 per cent. for wastage = 2·18 c. ft. per 100 square feet.	4 pieces 2 feet × 6 in. × 4 in. = 1·33 c. ft. per truss,	1 piece 15 in × 8 in. × 3 in. = ·21 c. ft.	1 piece 3 ft. × 8 in. × 4 in. = ·66 c. ft.	2½ in. × ¾ in. = ·013 c. ft. rg. ft.	4 in. × 1 in. = ·0277 c. ft. rg. ft.
XIV...	3	4½	3	5¾	4¼	6	5	7	2	3	2	2¾	2½	6¾	2½	7¾	15½	3	6½	2·10	...	...	...	...						
XVI...	3	5	3	6½	4¼	6	5	7¼	2¼	3¼	2	3	2½	7	2½	8	17	3	7½	2·66	...	...	...	...						
XVIII...	3¼	5¼	3¼	6¾	4½	6¼	5¼	7¼	2½	3½	2¼	3¼	2½	7¼	2½	8½	18½	3	8	3·08	11½	3¼	6½	1·69						
XX...	3½	5½	3½	6¾	4½	6½	5¼	7½	2½	3¾	2½	3½	2½	7½	2½	8¾	20	3½	9	4·37	12½	3½	7¼	2·20						
XXII...	3¾	5¾	3¾	7	4¾	6¾	5½	7¾	2¾	4	2¾	3¾	2½	7¾	2½	9½	21½	4	9¼	5·52	14	4½	7¾	3·39						
XXIV...	4	5¾	4	7¼	4¼	6	5	7	2¼	3	2	3	2½	6¾	2½	7¾	23	4	10¼	6·55	15	4½	8¼	3·87						
XXVI...	4	6¼	4	7¾	4¼	6¼	5	7¼	2¼	3¼	2¼	3	2½	7	2½	8	24½	4	11½	7·83	16	5	8¾	4·86						
XXVIII...	4¼	6½	4¼	8	4½	6¼	5¼	7½	2½	3½	2¼	3¼	2½	7¼	2½	8½	26	4½	12	9·75	17¼	5½	9½	6·26						
XXX...	4½	6½	4½	8	4½	6½	5¼	7½	2½	3¾	2½	3½	2½	7½	2½	8¾	27½	5	12½	11·94	18¼	6	10	7·60						

Note.—These dimensions are for a roof weighing 27 lbs. per square foot with 40 lbs. more allowed for wind pressure. The scantlings of the Purlins and common Rafters have been determined by the Deflection Formula, the Deflection allowed being $\frac{1}{10}$ of an inch to a foot.

TABLE XIX.—Scantlings for double tiled Verandah roof.

Span in Feet.	Verandah Posts.	Post Plates.			Principals.			Principals strutted. Alternative arrangement.				Purlins.			Hip Rafters.	Hip Rafters strutted. Alternative arrangement.		Common Rafters.
		Principals 8′ central distance.	Principals 9′ central distance.	Principals 10′ central distance.	8′ Central distance.	9′ Central distance.	10′ Central distance.	Principal. 8′ Central distance.	Principal. 9′ Central distance.	Principal. 10′ Central distance.	Struts.	Principals 8′ central distance.	Principals 9′ central distance.	Principals 10′ central distance.	Hip Rafters.	Hip Rafters.	Struts.	Common Rafters.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
V ...	4×4	4×5½	4×6¼	4×7	...	...	...	...	...	...	...	...	...	...	2¼×4¼	...	...	2×3¾
VI ...	4½×4	4×5¾	4×6½	4×7¼	...	...	...	...	...	...	...	...	...	...	3×5	...	...	2½×4
VII ...	4½×4½	4½×5¾	4½×6½	4½×7¼	...	...	...	..	...	..	...	...	...	...	3×6	...	...	3×4¼
VIII ...	4½×4½	4½×5	4½×5¾	4½×6½	4×7	4×7¼	4×7½	...	...	...	...	4½×5½	4½×6	5×6½	3½×7¼	...	...	2×3¼
IX ...	4½×4½	4½×5¼	4½×6	4½×6½	4×8	4×8¼	4×8½	...	...	...	...	4½×5½	4½×6¼	5×6¾	4×8	3×7½	3×3	2×3½
X ...	4½×4½	4½×5¼	4½×6	4½×6¾	4¼×8½	4½×8¾	4½×9	4×7	4×7½	4×7¾	3×3¾	4½×5¾	4¾×6¼	5¼×6¾	4×9¼	3×7¾	3×3½	2×3¾
XI ...	4¾×4¾	4¾×5½	4¾×6	4¾×6¾	4½×9¼	4¾×9½	4¾×9¾	4×7¾	4×8	4×8½	3×4	4½×6	5×6½	5¼×7	5×10¼	3¼×8½	3¼×4	2×4
XII ...	5×5	5×5½	5×6	5×6¾	4½×10	5×10	5×10½	4×8½	4×9	4×9½	3½×4	4½×6¼	5¼×6½	5½×7¼	5×11½	3½×9¼	3½×4	2½×4

Note.—The principal and hip rafters are strutted to the extent of ⅓rd of their length from the wall. For spans of XI and XII it will be found more convenient and economical to adopt the strut arrangement. Slope of roof 30°.

The *span* is the distance between the inner face of the Verandah post and the wall.

TABLE XX.—Scantlings for single tiled Verandah roof.

Span in Feet.	Verandah Posts.	Post Plates.			Principals.			Principals strutted. Alternative arrangement.				Purlins.			Hip Rafters.	Hip Rafters strutted. Alternative arrangement.		Common Rafters.
		Principals 8′ central distance.	Principals 9′ central distance.	Principals 10′ central distance.	8′ Central distance.	9′ Central distance.	10′ Central distance.	Principals. 8′ Central distance.	9′ Central distance.	10′ Central distance.	Strut.	Principals 8′ central distance.	Principals 9′ central distance.	Principals 10′ central distance.		Hip Rafter.	Strut.	
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
V ...	4×4	4×5	4×5¾	4×6½	...	...	...	...	...	..	...	...	...	...	2½×3¾	...	...	2×3½
VI ...	4½×4	4×5¼	4×6	4×6¾	...	...	...	...	...	...	..	...	...	...	2½×5	...	...	2×4
VII ...	4½×4½	4½×5¼	4½×6	4½×6¾	...	...	...	...	...	...	...	...	...	...	3×5½	...	...	2¼×4¼
VIII ...	4½×4½	4½×4¾	4½×5¼	4½×6	4×6½	4×6¾	4×7	...	...	...	...	4×5¼	4½×5½	4½×6¼	3×7¼	...	..	1¾×3
IX ...	4½×4½	4½×5	4½×5½	4½×6¼	4×7¼	4¼×7½	4×8	...	...	...	...	4×5½	4½×5¾	4¾×6¼	3½×7¾	3×7¼	3×2¾	2×3¼
X ...	4½×4½	4½×5	4½×5¾	4½×6¼	4×8¼	4×8½	4½×8½	3¾×6½	4×6½	4×7	3×3½	4¼×5½	4½×6	5×6½	4×8¾	3×7½	3×3	2×3½
XI ...	4¾×4¾	4¾×5	4¾×5½	4¾×6¼	4½×8½	4½×9	4½×9¼	4×7	4×7½	4×7¾	3×4	4½×5½	4½×6¼	5×6¾	4×10	3×8	3×4	2×3¾
XII ...	5×5	5×5	5×5½	5×6¼	4½×9½	4½×9¾	4½×10	4×7½	4×8	4×8½	3×4	4½×5¾	4¾×6¼	5¼×6¾	4½×10¾	3×9	3×4	2×4

Note.—The principal and hip rafters are strutted to the extent of ⅓rd of their length from the wall. For spans of XI & XII it will be found more convenient and economical to adopt the strut arrangement. Slope of roof 30°.

The *span* is the distance between the inner face of the Verandah post and the wall.

TABLE XXI.—Scantlings of Teakwood Trusses 10 feet apart for Corrugated Iron Roofs.

Spans.	Tie Beam.				Principals.				King Post.				Struts.				Total C. F. of Truss.
	Length'.	Breadth".	Depth".	Contents C. F.	Length'.	Breadth".	Depth".	Contents of 2 C. F.	Length'.	Breadth".	Depth".	Contents C. F.	Length'.	Breadth".	Depth".	Contents of 2 C. F.	
XII ...	15	3	3	·93	10½	3	4	1·75	4½	6	3	·56	3½	2½	2	·24	3·48
XIV ...	17 No. 2	3	3	1·06	11½	3	4½	2·15	5¼	6	3	·65	4¼	2½	2¼	·33	4·19
XVI ...	10¼	3	3½	1·49	12¾	3	4¾	2·52	5¾	6	3	·71	4¾	2¾	2½	·45	5·17
XVIII ...	11¼	3¼	3¾	1·90	13¾	3¼	4¾	2·94	6½	6	3¼	·88	5¼	3	2½	·54	6·26
XX ...	12¼	3½	3¾	2·23	15	3½	5	3·64	7	6	3½	1·02	6	3¼	2¾	·74	7·63
XXII ...	13¼	3½	4	2·57	16¼	3½	5¼	4·14	7½	6	3½	1·09	6½	3¼	3	·88	8·68

Note.—These dimensions are for a roof weighing 5 lbs. per square foot with 40 lbs. more allowed for wind pressure.

Purlins to be $3\frac{1}{2}'' \times 5\frac{1}{4}''$ at 3 feet central distances.

TABLE XXII.—Straps and Bolts for Trusses of Roofs of various Spans.

Span of Roof.	Connecting Principal and Tie-beam.			Connecting Tie-beam and King or Queen Post.				Distance between end of strap of Bolt.		Fish Plates and Bolts when required.	
	Diameter of Bolt.	Strap.		Diameter of Bolt.	Strap.			Principal and Tie-beam.	King Post and Tie-beam.	Bolts.	Plates.
		Thick.	Wide.		Thick.	Wide.					
XII ...	¾″	⅜″	1¼″	⅝″	⅜″	¾″		1″	¾″	Bolts to be 1 inch square 6 in number at 6″ intervals counting from joint.	$\frac{5}{16}$ inch plate 10 times depth of Beam in length one on each side (not above and below) with ends clawed into timber.
XIV ...	¾″	⅜″	1¼″	⅝″	⅜″	¾″		1″	¾″		
XVI ...	¾″	⅜″	1½″	⅝″	⅜″	1″		1″	¾″		
XVIII ...	¾″	⅜″	1¾″	⅝″	⅜″	1″	King Posts.	1¼″	¾″		
XX ...	1″	⅜″	1¾″	¾″	⅜″	1″		1¼″	¾″		
XXII ...	1″	⅜″	1¾″	¾″	⅜″	1″		1½″	¾″		
XXIV ...	1″	⅜″	2¼″	¾″	⅜″	1″		1¾″	¾″		
XXVI ...	1″	½″	2¼″	¾″	⅜″	1″	Queen Posts.	1¾″	¾″		
XXVIII ...	1″	½″	2¼″	¾″	⅜″	1″		1¾″	¾″		
XXX ...	1″	½″	2¼″	¾″	⅜″	1″		1¾″	¾″		

N.B.—These dimensions are for a roof weighing 33½ lbs. per square foot with 30 lbs. more allowed for wind pressure.

TABLE XXIII.—Scantlings for Timber-topped Culverts, Single Spans.

For clear Road-way of 18 Feet.

Description of Scantlings.	4 ft. Span.					5 ft. Span.					6 ft. Span.				
	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.
		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.
Girders	6	5 6	3	5	3·44	6	6 6	$3\frac{1}{4}$	$5\frac{1}{2}$	4·84	6	7 6	$3\frac{3}{4}$	$6\frac{1}{4}$	7·32
Wall plates to girders... ...	4	9 0	4	3	3·00	4	9 0	4	3	3·00	4	9 0	4	3	3·00
Railing. Sill	2	9 0	4	5	2·50	2	10 0	4	5	2·78	2	11 0	4	5	3·06
Railing. Top rail	2	4 6	4	4	1·00	2	5 6	4	4	1·22	2	6 6	4	4	1·44
Railing. Middle rail	2	4 6	4	3	·75	2	5 6	4	3	·92	2	6 6	4	3	1·08
Railing. End posts..	4	3 3	4	4	1·44	4	3 3	4	4	1·44	4	3 3	4	4	1·44
Railing. Intermediate posts ...			None.					None.			2	2 6	4	4	0·55
Railing. End struts	4	3 3	3	4	1·08	4	3 3	3	4	1·08	4	3 3	3	4	1·08
Railing. Side struts	4	2 9	3	3	·69	4	2 9	3	3	·69	6	2 9	3	3	1·03
Planking	5	11 5	8	3	9·51	6	11 5	$8\frac{3}{4}$	3	12·49	6	11 5	$9\frac{1}{4}$	3	13·20
Do.	5	8 2	8	3	6·80	6	8 2	$8\frac{3}{4}$	3	8·93	6	8 2	$9\frac{1}{4}$	3	9·44
Do. Projected to carry struts	2	13 5	9	3	5·03	2	13 5	9	3	5·03	3	13 5	9	3	7·55
	2	10 2	9	3	3·81	2	10 2	9	3	3·81	3	10 2	9	3	5·72
			Total	c. ft.	39·05			Total	c. ft.	46·23			Total	c. ft.	55·91

TABLE XXIII.—Scantlings for Timber-topped Culverts, Single Spans—*continued.*

For clear Road-way of 18 Feet.

Description of Scantlings.	8 ft. Span.					10 ft. Span.					12 ft. Span.				
	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.
		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.
Girders	6	9 6	$4\frac{3}{4}$	$7\frac{3}{4}$	14·57	6	12 0	$5\frac{1}{2}$	$9\frac{1}{4}$	25·44	6	14 0	$6\frac{1}{2}$	$10\frac{1}{2}$	39·81
Wall plates to girders ...	4	9 0	$4\frac{1}{2}$	3	3·37	4	9 0	5	$3\frac{1}{2}$	4·37	4	9 0	5	$3\frac{1}{2}$	4·37
Railing. Sill	2	13 0	4	5	3·61	2	15 0	4	5	4·17	4	9 0	4	5	5·00
Railing. Top rail	2	8 6	4	4	1·89	2	10 6	4	4	2·33	2	12 6	4	4	2·78
Railing. Middle rail	2	8 6	4	3	1·42	2	10 6	4	3	1·75	2	12 6	4	3	2·08
Railing. End posts	4	3 3	4	4	1·44	4	3 3	4	4	1·44	4	3 3	4	4	1·44
Railing. Intermediate posts ...	2	2 6	4	4	·55	2	2 6	4	4	·55	4	2 6	4	4	1·11
Railing. End struts	4	3 3	3	4	1·08	4	3 3	3	4	1·08	4	3 3	3	4	1·08
Railing. Side struts	6	2 9	3	3	1·03	6	2 9	3	3	1·03	8	2 9	3	3	1·37
Planking	8	11 5	10	3	19·03	10	11 5	$10\frac{1}{4}$	3	24·38	12	11 5	$9\frac{3}{4}$	3	27·83
Do.	8	8 2	10	3	13·61	10	8 2	$10\frac{1}{4}$	3	17·44	12	8 2	$9\frac{3}{4}$	3	19·91
Do. Projected to carry struts	3	13 5	9	3	7·55	3	13 5	9	3	7·55	4	13 5	9	3	10·06
	3	10 2	9	3	5·72	3	10 2	9	3	5·72	4	10 2	9	3	7·62
			Total	c. ft.	74·87			Total	c. ft.	97·25			Total	c. ft.	124·46

TABLE XXIII.—Scantlings for Timber-topped Culverts, Single Spans—*continued.*

For clear Road-way of 18 Feet.

Description of Scantlings.	15 ft. Span.					18 ft. Span.					20 ft. Span.				
	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.	Number.	Length.	Breadth.	Depth.	Cubic Contents.
		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.		Ft. In.	In.	In.	Ft.
Girders	6	17 6	$7\frac{1}{2}$	$12\frac{1}{2}$	68·36	6	21 0	$8\frac{1}{2}$	$14\frac{1}{2}$	107·84	6	23 6	$9\frac{1}{2}$	$15\frac{1}{2}$	144·18
Wall plates to girders... ...	4	9 0	6	4	6·00	4	9 0	6	4	6·00	4	9 0	6	4	6·00
Railing. Sill	4	10 6	4	5	5·83	4	12 0	4	5	6·67	4	13 0	4	5	7·22
Railing. Top rail	2	11 0	4	4	3·78	4	10 0	4	4	4·44	4	11 0	4	4	4·89
	2	6 0													
Railing. Middle rail	6	5 0	4	3	2·50	8	4 6	4	3	3·00	8	5 0	4	3	3·33
Railing. End posts	4	3 3	4	4	1·44	4	3 3	4	4	1·44	4	3 3	4	4	1·44
Railing. Intermediate posts ...	4	2 6	4	4	1·11	6	2 6	4	4	1·67	6	2 6	4	4	1·67
Railing. End struts...	4	3 3	3	4	1·08	4	3 3	3	4	1·08	4	3 3	3	4	1·08
Railing. Side struts	8	2 9	3	3	1·37	10	2 9	3	3	1·72	10	2 9	3	3	1·72
Planking	15	11 5	$10\frac{1}{4}$	3	36·57	20	11 5	9	3	42·81	20	11 5	10	3	47·57
Do.	15	8 2	$10\frac{1}{4}$	3	26·16	20	8 2	9	3	30·62	20	8 2	10	3	34·03
Do. Projected to carry	4	13 5	9	3	10·06	5	13 5	9	3	12·58	5	13 5	9	3	12·58
struts ...	4	10 2	9	3	7·62	5	10 2	9	3	9·53	5	10 2	9	3	9·53
			Total	c. ft.	171·88			Total	c. ft.	229·4			Total	c. ft.	275·24

TABLE XXIV.—Iron Work for Timber-topped Culverts—accompaniment to Table XXIII.

Description.	4 and 5 ft. Spans.					6, 8 and 10 ft. Spans.					12 and 15 ft. Spans.					18 and 20 ft. Spans.				
	Number.	Length.	Breadth.	Thickness.	Weight in lbs.	Number.	Length.	Breadth.	Thickness.	Weight in lbs.	Number.	Length.	Breadth.	Thickness.	Weight in lbs.	Number.	Length.	Breadth.	Thickness.	Weight in lbs.
(Straps to be countersunk.)		Ft. In.	In.	In.			Ft. In.	In.	In.			Ft. In.	In.	In.			Ft. In.	In.	In.	
Securing the top rail to the end posts.	8	1 0	$1\frac{1}{4}$	$\frac{3}{16}$	6·24	8	1 0	$1\frac{1}{4}$	$\frac{3}{16}$	6·24	8	1 0	$1\frac{1}{4}$	$\frac{3}{16}$	6·24	8	1 0	$1\frac{1}{4}$	$\frac{3}{16}$	6·24
Do. do. intermediate.	..	..	none	..	..	2	1 4	$1\frac{1}{4}$	$\frac{3}{16}$	2·08	4	1 4	$1\frac{1}{4}$	$\frac{3}{16}$	4·16	6	1 4	$1\frac{1}{4}$	$\frac{3}{16}$	6·24
Holding down plates in the masonry.	4	1 0	8	$\frac{1}{4}$	26·67	4	1 0	8	$\frac{1}{4}$	26·67	4	1 0	8	$\frac{1}{4}$	26·67	4	1 0	8	$\frac{1}{4}$	26·67
Total ..					32·91					34·99					37·07					39·15
Bolts.	No.	L.	Diar.	T.	Weight.	No.	L.	Diar.	T.	Weight.	No.	L.	Diar.	T.	Weight.	No.	L.	Diar.	T.	Weight.
Holding down, securing sill to masonry	8	2 0	$\frac{3}{4}$	..	23·62	8	2 0	$\frac{3}{4}$	..	23·62	8	0 2	$\frac{3}{4}$	..	23·62	8	2 0	$\frac{3}{4}$	..	23·62
Square heads and nuts to do. ..	8	·55 lbs. per pair.			4·40	8	·55 lbs. per pair.			4·40	8	·55 lbs. per pair.			4·40	8	·55 lbs. per pair.			4·40
Washers to do.	8	..	$1\frac{3}{4}$	$\frac{1}{8}$	·55	8	..	$1\frac{3}{4}$	$\frac{1}{8}$	·55	8	..	$1\frac{3}{4}$	$\frac{1}{8}$	·55	8	..	$1\frac{3}{4}$	$\frac{1}{8}$	·55
To straps securing top rail to end posts..	12	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	2·26	12	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	2·26	12	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	2·26	12	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	2·26
Do. do. intermediate do. ..	..	..	none.	..	..	2	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	·38	4	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	·75	6	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	1·13
Bolts securing end struts to sill	4	1 0	$\frac{1}{2}$	..	2·62	4	1 0	$\frac{1}{2}$	..	2·62	4	1 0	$\frac{1}{2}$	..	2·62	4	1 0	$\frac{1}{2}$	..	2·62
Do. side do. top and bottom..	8	0 8	$\frac{1}{2}$	..	3·50	12	0 8	$\frac{1}{2}$	..	5·25	16	0 8	$\frac{1}{2}$	..	7·00	20	0 8	$\frac{1}{2}$	..	8·75
Strap do. posts to sill and planking..	4	0 $11\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{8}$	5·98	6	0 $11\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{8}$	8·97	8	0 $11\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{8}$	11·96	10	0 $11\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{8}$	14·95
Bolts to do. through sill and post.	8	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	1·51	12	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	2·26	16	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	3·01	20	0 $4\frac{1}{2}$	$\frac{7}{16}$	..	3·76
Add—for square heads and nuts to above .. (To $\frac{1}{2}$ in. bolt. / To $\frac{7}{16}$ in bolt.) Pairs.	12	164 lbs. per pair.			1·97	16	·164 lbs. per pair.			2·62	20	·164 lbs. per pair.			3·28	24	·164 lbs. per pair.			3·94
	20	12 lbs. per pair.			2·40	26	12 lbs. per pair.			3·12	32	·12 lbs. per pair.			3·84	38	·12 lbs. per pair.			4·56
Do. Washers to above	32	..	$1\frac{1}{2}$	$\frac{1}{8}$	1·80	42	..	$1\frac{1}{2}$	$\frac{1}{8}$	2·36	32	..	$1\frac{1}{2}$	$\frac{1}{8}$	2·92	62	..	$1\frac{1}{2}$	$\frac{1}{8}$	3·50
Total weights lbs. ..					50·61					58·41					66·21					74·04
Spikes for planking 6" long, 6 in one lb. — Weight in lbs.	7	8				9	11	13			16	19				25	25			
Spikes for planking 6" long, 6 in one lb. — Number.	42	48				54	66	78			96	114				150	150			
Spikes for planking 6" long, 6 in one lb. — Span.	4	5				6	8	10			12	15				18	20			

Memo. explanatory of the following Tables of Task Work in different soils.

The table has been drawn up for the purpose of determining and arranging in a systematic manner the quantities of work required as daily tasks from men, women, and children engaged upon the construction of earth-work, and has proved particularly useful where large bodies of work-people, such as famine or extra-mural labour, have been employed.

The work-people should be divided into gangs, each gang consisting of fifty people—men, women, and children—under one mukádam; six gangs being placed under one mustering kárkún.

The following example illustrates the use of the Table:—

Assume a gang consisting of 20 men + 20 women + 10 children to be working with a lift varying from 6 to 10 feet and a lead varying from 200 to 300 feet in soft muram.

In the column including this lift and lead, the relative tasks for one man, one woman and one child is as follows:—

48, 32 and 16 cubic feet respectively—

Then $48 \times 20 = 960$ = task of 20 men.
$32 \times 20 = 640$ „ „ 20 women.
$16 \times 10 = 160$ „ „ 10 children.

1,760 cubic feet = total task to be executed by the gang, if the material were black or red soil, but as the example refers to soft muram, the multiplier, 0·82 (see foot-note to Table) must be used:

∴ Total task = $1{,}760 \times 0{\cdot}82 = 1{,}443{\cdot}20$ cubic feet, and this is given to the mukádam in round numbers. Thus in the case of a puddle trench 10 feet in width the task would be given as follows:—

Length.		Width.		Depth.
140 feet	×	10 feet	×	1 foot.

In the construction of a dam where the earth is put on in layers of uniform thickness, tasks should be measured on the dam.

For breaking lumps of earth, spreading and making the layers uniform, two men should be allowed for each gang,—that is, one man for each twenty-five people employed.

In puddling, in layers of one foot in thickness, three men should complete, including cutting, treading and covering, a space of 25 feet × 10 feet or 250 cubic feet in one day.

In "ramming" with a rammer weighing 30 lbs., one man should complete 500 square feet per day.

The following Tables have reference more especially to earth-work in large dams and embankments.

TABLE XXV.

Table showing an average day's work per man, woman and child under different "lifts" and "leads" in black or red soil.

Lift, Feet.		Lead, Feet.		Average Day's Work, Cubic Feet.		
From	To	From	To	Man.	Woman.	Child.
...	5	...	50	76	51	25
inclusive.		50	100	70	47	23
		100	200	64	43	21
		200	300	59	39	20
		300	400	53	35	18
		400	500	48	32	16
		500	600	42	28	14
		600	700	36	24	12
		700	800	30	20	10
		800	900	24	16	8
		900	1,000	18	12	6
5	10	...	100	56	37	19
inclusive.		100	200	52	35	17
		200	300	48	32	16
		300	400	44	29	15
		400	500	40	27	13
		500	600	35	23	12
		600	700	31	21	10
		700	800	27	18	9
		800	900	22	15	7
		900	1,000	17	11	6
10	15	...	100	48	32	16
inclusive.		100	200	45	30	15
		200	300	41	27	14
		300	400	38	25	13
		400	500	34	23	11
		500	600	30	20	10
		600	700	27	18	9
		700	800	24	16	8
		800	900	20	13	7
		900	1,000	16	11	5
15	20	...	100	42	28	14
inclusive.		100	200	39	26	13
		200	300	36	24	12
		300	400	33	22	11
		400	500	30	20	10
		500	600	27	18	9
		600	700	24	16	8
		700	800	21	14	7
		800	900	18	12	6
		900	1,000	15	10	5

TABLE XXV—*continued.*

Table showing an average day's work per man, woman and child under different "lifts" and "leads" in black or red soil.

Lift, Feet.		Lead, Feet.		Average Day's Work, Cubic Feet.		
From	To	From	To	Man.	Woman.	Child.
20	25	...	100	37	25	12
inclusive.		100	200	35	23	12
		200	300	32	21	11
		300	400	30	20	10
		400	500	27	18	9
		500	600	25	17	8
		600	700	22	15	7
		700	800	19	13	6
		800	900	17	11	6
		900	1,000	14	9	5
25	30	...	100	33	22	11
inclusive.		100	200	31	21	10
		200	300	29	19	10
		300	400	27	18	9
		400	500	25	17	8
		500	600	23	15	8
		600	700	21	14	7
		700	800	19	13	6
		800	900	16	11	5
		900	1,000	13	9	4
30	35	...	100	30	20	10
inclusive.		100	200	28	19	9
		200	300	26	17	9
		300	400	24	16	8
		400	500	22	15	7
		500	600	20	13	7
		600	700	18	12	6
		700	800	16	11	5
		800	900	14	9	5
		900	1,000	12	8	4
35	40	...	100	28	19	9
inclusive.		100	200	26	17	9
		200	300	24	16	8
		300	400	22	15	7
		400	500	20	13	7
		500	600	18	12	6
		600	700	16	11	5
		700	800	14	9	5
		800	900	13	9	4
		900	1,000	12	8	4

TABLE XXV—*continued.*

Table showing an average day's work per man, woman and child under different "lifts" and "leads" in black or red soil.

Lift, Feet.		Lead, Feet.		Average Day's Work, Cubic Feet.		
From	To	From	To	Man.	Woman.	Child.
40	45	..	100	26	17	9
inclusive.		100	200	24	16	8
		200	300	23	15	8
		300	400	21	14	7
		400	500	20	13	7
		500	600	18	12	6
		600	700	17	11	6
		700	800	15	10	5
		800	900	13	9	4
		900	1,000	11	7	4
45	50	...	100	24	16	8
inclusive.		100	200	23	15	8
		200	300	21	14	7
		300	400	20	13	7
		400	500	18	12	6
		500	600	17	11	6
		600	700	15	10	5
		700	800	14	9	5
		800	900	12	8	4
		900	1,000	10	7	3
50	55	...	100	22	15	7
inclusive.		100	200	21	14	7
		200	300	20	13	7
		300	400	18	12	6
		400	500	16	11	5
		500	600	15	10	5
		600	700	14	9	5
		700	800	13	9	4
		800	900	12	8	4
		900	1,000	10	7	3
55	60	...	100	21	14	7
inclusive.		100	200	20	13	7
		200	300	18	12	6
		300	400	17	11	6
		400	500	15	10	5
		500	600	14	9	5
		600	700	13	9	4
		700	800	12	8	4
		800	900	10	7	3
		900	1,000	9	6	3

The above quantities must be multiplied for soft muram by 0·82 } Excavation.
Average ,, by 0·64 }
Hard ,, by 0·46 }
Loose earth or sand by ... 1·25 } Spoil.
Loose muram by ... ... 1·00 }

TABLE XXVI.

Task Work for General Excavation in different soils in ordinary road works.

Lead in Feet.		Lift in Feet.	Black or Red Soil, C. F.	Muram, Cubic Feet.			Loose Earth or Sand, C.F.
From	To			Soft.	Average.	Hard.	
...	50	0 to 5.	65	53	42	30	81
50	100		60	49	38	28	75
100	200		55	45	35	25	69
200	300		50	41	32	23	63
300	400		45	36	29	21	56
400	500		41	34	26	19	51
500	600		36	30	23	17	45
...	100	5 to 10.	48	39	31	22	60
100	200		44	36	28	20	55
200	300		41	34	26	19	51
300	400		38	31	24	17	48
400	500		34	28	22	16	43
500	600		30	25	19	14	38
...	100	10 to 15.	41	34	26	19	51
100	200		38	31	24	17	48
200	300		35	29	22	16	44
300	400		33	27	21	15	41
400	500		29	24	19	13	36
500	600		26	21	17	12	33
...	100	15 to 20.	36	30	23	17	45
100	200		33	27	21	15	41
200	300		31	25	20	14	39
300	400		28	23	18	13	35
400	500		26	21	17	12	33
500	600		23	19	15	11	29

Note.—A woman can perform $\frac{2}{3}$ work of man.
Each child do. $\frac{1}{2}$ do. of woman.

TABLES FOR ASCERTAINING COST OF CARRIAGE BY COOLIES AND CARTS.

Memorandum on Cost of Carriage.

When any quantity of materials of given weight or cubic content (L) has to be moved to any distance (d), in feet, by a succession of trips of a number of units of conveyance, whose load in lbs. or cubic feet is (l), then the cost of transport of (L) will depend

1stly, on X, or the proportion of (L) to (l); that is, the number of unit-loads, or trips of a unit of conveyance, that will be necessary.

2ndly, on Y, or the fraction of a working day, taken by a unit to make one trip to (d) and back.

3rdly, on Z, or the hire of a unit of conveyance for a working day.

In fact the cost of transport will $= X \times Y \times Z$.

To make tables for all possible values of Z would be beyond the scope of this memorandum. The following tables, however, give some useful values of Y for various leads, also of $X \times Y$ for a few given values of X or $\frac{L}{l}$

The calculation of Y requires the following data :—

M, the number of minutes in a working day.

t, the time in minutes taken to load and unload a unit.

*s, the average speed in feet per minute of a unit. If also for convenience of notation.

T, represent the time in minutes taken for a unit to make one trip to (d) and back.

N, be the number of such trips made in a working day.

then (1) $$T = \frac{2d}{s} + t.$$

(2) $$N = \frac{M}{T} = \frac{M}{\frac{2d}{s} + t.}$$

(3) $$Y = \frac{T}{M} = \frac{\frac{2d}{s} + t}{M} = \frac{1}{N}$$

* *Note.*—S, the average speed, is the harmonic mean between the observed or known speeds s′ s″ of the unit when loaded and unloaded respectively, i. e $= \frac{2\,s'\,s''}{s' + s''}$

If T be observed as well as t, then from (1) $S = \frac{2d}{T - t.}$

TABLE XXVII.

When unit of conveyance = COOLY LOAD, or $l = \frac{1}{80}$ cubic foot.
DATA; M = 500 minutes, t = ½ minute, s = 200 feet, d as per column I.
Formulæ $T = \frac{2d}{s} + t$; $N = \frac{M}{T}$; $Y = \frac{T}{M}$; $X = \frac{L}{l}$; Z = daily hire of unit.
Cost of transport of quantity L to d = X × Y × Z.

I.	II.	III.	IV.	V.	I.	II.	III.	IV.	V.
Lead or distance in feet.	No. of trips to d. and back in a day.	Time of a trip to d. and back in minutes.	Fraction of a day taken to make one trip to d. and back expressed in decimals.	X×Y when L = ¼C.F. L = 100 cubic feet, i.e. X×Y = 200 Y.	Lead or distance in feet.	No. of trips to d. and back in a day.	Time of a trip to d. and back in minutes.	Fraction of a day taken to make one trip to d and back expressed in decimals.	X×Y when L = ¼C.F. L = 100 cubic feet, i.e. X×Y = 200 Y.
d.	N.	T.	Y.	X×Y	d.	N.	T.	Y.	X×Y.
20	714	·70	·0014	·28	475	95	5·25	·0105	2·10
30	625	·80	·0016	·32	500	91	5·50	·0110	2·20
40	556	·90	·0018	·36	525	87	5·75	·0115	2·30
50	500	1·00	·0020	·40	550	83	6·00	·0120	2·40
60	455	1·10	·0022	·44	575	80	6·25	·0125	2·50
70	417	1·20	·0024	·48	600	77	6·50	·0130	2·60
80	385	1·30	·0026	·52	625	72	6·65	·0135	2·70
90	357	1·40	·0028	·56	650	71	7·00	·0140	2·80
100	333	1·50	·0030	·60	675	69	7·25	·0145	2·90
125	286	1·75	·0035	·70	700	67	7·50	·0150	3·00
150	250	2·00	·0040	·80	750	63	8·00	·0160	3·20
175	222	2·25	·0045	·90	800	59	8·50	·0170	3·40
200	200	2·50	·0050	1·00	850	56	9·00	·0180	3·60
225	182	2·75	·0055	1·10	900	53	9·50	·0190	3·80
250	167	3·00	·0060	1·20	950	50	10·00	·0200	4·00
275	154	3·25	·0065	1·30	1000	48	10·50	·0210	4·20
300	143	3·50	·0070	1·40	1050	45	11·00	·0220	4·40
325	133	3·75	·0075	1·50	1100	43	11·50	·0230	4·60
350	125	4·00	·0080	1·60	1150	42	12·00	·0240	4·80
375	118	4·25	·0085	1·70	1200	40	12·50	·0250	5·00
400	111	4·50	·0090	1·80	1250	38	13·00	·0260	5·20
425	105	4·75	·0095	1·90	1300	37	13·50	·0270	5·40
450	100	5·00	·0100	2·00	1320	36·5	13·75	·0275	5·50

N.B.—Quantity carried in a day is N unit-loads.
Cost of carrying one cooly load to d = Y × hire of cooly; of 100 C.F. of any materials is X × Y × hire of cooly.

Example.

What would be cost of removing 100 C. F. to 600 feet if coolies cost 3 annas a day.

Ans. 2·6 × 3 = 7·8 annas.

TABLE XXVIII.

When unit of conveyance = CART LOAD or l has the values in Columns V. to XII.
DATA: M = 540 minutes. t = 10 minutes. s = 100 feet. d as per column I.

Formulæ: $T = \frac{2d}{s} + t$; $N = \frac{M}{T}$; $Y = \frac{T}{M}$; $X = \frac{L}{l}$; Z = daily hire of unit.

Cost of transport of quantity L to d = X × Y × Z.

d.	N.	T.	Y.	X × Y FOR THE UNDERMENTIONED VALUE OF L AND l.							
				L=100 CUBIC FEET.					L=1 TON.		
Lead or distance in feet.	No. of trips to d and back in a day.	Time of a trip to d and back in minutes.	Fraction of a day taken to make one trip to d and back expressed in decimals.	l. in C. F. 6	l. in C. F. 7.	l. in C. F. 8.	l. in C. F. 9.	l. in C. F. 10.	l. in cwt. 8.	l. in cwt. 9.	l. in cwt. 10.
I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.
400	30	18	·0333	·556	·476	·416	·370	·333	·0825	·0730	·0666
431	29	18·6	·0345	·575	·493	·431	·383	·345	·0863	·0766	·0690
482	28	19·6	·0357	·595	·510	·446	·397	·357	·0895	·0793	·0714
500	27	20	·0370	·617	·529	·463	·411	·370	·0925	·0826	·0740
540	26	20·8	·0384	·640	·549	·480	·427	·384	·0960	·0853	·0768
580	25	21·6	·0400	·666	·572	·500	·444	·400	·1000	·0889	·0800
625	24	22·5	·0416	·693	·594	·520	·416	·416	·1040	·0925	·0832
675	23	23·5	·0435	·724	·621	·544	·483	·435	·1087	·0966	·0870
730	22	24·5	·0454	·757	·649	·567	·504	·454	·1135	·1009	·0908
785	21	25·7	·0476	·793	·680	·595	·529	·476	·1202	·1068	·0952
850	20	27	·0500	·833	·714	·625	·555	·500	·1250	·1111	·1000
921	19	28·4	·0526	·877	·751	·657	·584	·526	·1315	·1169	·1052
1,000	18	30	·0555	·925	·793	·694	·617	·555	·1389	·1234	·1111
1,088	17	31·8	·0588	·980	·840	·735	·653	·588	·1470	·1307	·1176
1,188	16	33·7	·0625	1·042	·893	·781	·694	·625	·1560	·1390	·1250
1,300	15	36	·0666	1·111	·952	·833	·740	·666	·1666	·1480	·1330
1,428	14	38·5	·0714	1·190	1·020	·893	·793	·714	·1787	·1590	·1430
1,575	13	41·5	·0769	1·282	1·099	·961	·854	·769	·1925	·1710	·1540
1,750	12	45	·0833	1·389	1·190	1·042	·926	·833	·2080	·1850	·1660
1,955	11	49	·0909	1·515	1·299	1·136	1·010	·909	·2280	·2020	·1820
2,200	10	54	·1000	1·666	1·429	1·250	1·111	1·000	·2500	·2220	·2000
2,500	9	60	·1111	1·852	1·587	1·389	1·234	1·111	·2770	·2470	·2220
2,675	8·5	63·5	·1176	1·960	1·680	1·470	1·307	1·176	·2940	·2610	·2350
2,875	8	67·5	·1250	2·083	1·786	1·563	1·389	1·250	·3130	·2770	·2500
3,100	7·5	72	·1333	2·222	1·904	1·666	1·481	1·333	·3330	·2960	·2660
3,355	7	77	·1428	2·383	2·040	1·784	1·587	1·428	·3560	·3170	·2850
3,653	6·5	83	·1538	2·563	2·197	1·922	1·709	1·538	·3840	·3410	·3070
4,000	6	90	·1666	2·777	2·381	2·083	1·852	1·666	·4170	·3700	·3330
4,425	5·5	98·5	·1818	3·030	2·597	2·273	2·020	1·818	·4540	·4030	·3630
4,900	5	108	·2000	3·333	2·857	2·500	2·222	2·000	·5000	·4450	·4000
5,500	4·5	120	·2222	3·703	3·174	2·777	2·409	2·222	·5550	·4940	·4440
6,200	4	135	·2500	4·166	3·571	3·125	2·777	2·500	·6250	·5560	·5000
7,200	3·5	154	·2857	4·762	4·082	3·573	3·174	2·857	·7140	·6340	·5710
8,500	3	180	·3333	5·555	4·762	4·167	3·704	3·333	·8330	·7410	·6660
10,300	2·5	216	·4000	6·666	5·714	5·000	4·444	4·000	1·000	·8890	·8000
13,000	2	270	·5000	8·333	7·143	6·250	5·555	5·000	1·250	1·111	1·000
17,500	1·5	360	·6666	11·111	9·524	8·333	7·407	6·666	1·670	1·480	1·333
26,500	1	540	1·000	16·666	14·286	12·500	11·111	10·00	2·500	2·220	2·000
53,500	0·5	1,080	2·000	33·333	28·572	25·000	22·222	20·00	5·000	4·440	4·000

Example.

Cost of carrying 100 cubic feet metal 2,200 feet, if cart hired at 12 as. a day takes 8 cubic feet as its load, = 1·25 × hire of cart per day = 1·25 × 12 = 15 as.

TABLES FOR THE CALCULATION OF EARTHWORK.

Description of the Tables.

The following two series of Tables are intended to facilitate the calculation of earth-work in cuttings and embankments in the preparation of projects for roads and canals. They are based on the prismoidal formula, and the results obtained therefrom will be, therefore, absolutely correct. It is impossible, of course, to furnish Tables which shall include all widths of formation, side slopes, or even all possible heights of section. To limit, therefore, the number of such, only certain side slopes frequently adopted in practice, *viz.*, ½ to 1, 1 to 1, 1½ to 1, and 2 to 1, have been provided for; to any other than these the following tables would not apply at all.

Next, in regard to the limit assigned to widths of formation and for which the prismoidal mean area has been duly calculated and tabulated, it will be noted that the bases adopted are 18, 20, 22, 24, and 26 feet. These have been selected as being probably more useful than any other. Each of these bases has been calculated to each of the side slopes stated above, and to sections the height of which at either end does not exceed 20 feet. This series of Tables is numbered from XXIX to XLVIII.

For widths of formation other than the above, or for heights of section over 20 feet (but under 40 feet) at either end, recourse must be had to the series of Tables numbered from XLIX to LXXX from which the prismoidal mean area for *any* base and for *any* height up to 40 feet, may be calculated in the way shown below. In the practical application of this second series of Tables two multiplications will be needed, instead of one only as in the first series, in order to determine the cubical content of a given length of cutting or embankment. First the prismoidal mean area has to be ascertained, and this then multiplied by the length of such section in *feet*; the result arrived at will be in *cubic yards*.

This second series of Tables from XLIX to LXXX is, it may be stated, a mere reprint of a portion of the "Tables for facilitating the calculation of earth-work" published by Sir John MacNeill, and the results obtained therefrom are, as is well known, in *cubic yards*. The first series of Tables from XXIX to XLVIII, which are for the specific bases and side slopes above stated, have been calculated entirely from Sir John MacNeill's work by the present compiler. In order to conform, however, to the practice in force in the Public Works Department of calculating the volumes of earth-work in *cubic feet*, and also to save labour, the tabular numbers given in these Tables, or in other words the prismoidal mean areas are given in *square feet*. These when multiplied by the length of the section also in feet, will, of course, give the result in *cubic feet*. It is necessary to bear this in mind when using these Tables.

Sections of Ground

Fig. I. (Cutting)

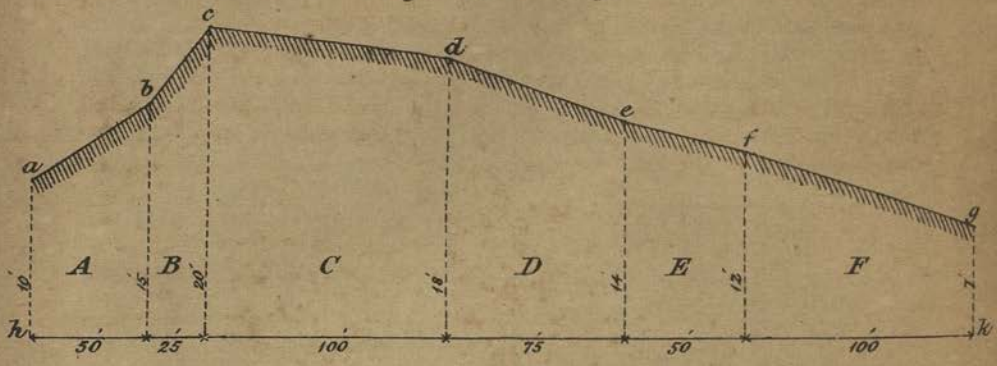


Fig. II.

Fig. III. (Embankment)

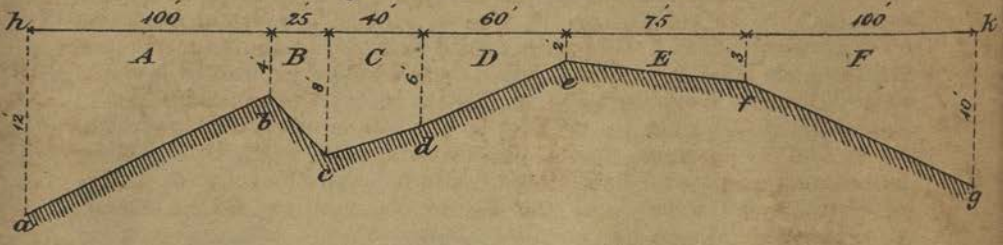
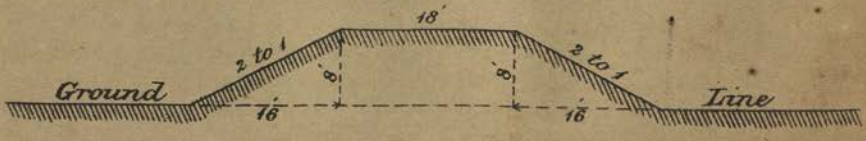


Fig. IV.



Govt Photozinco Office, Poona 1887.

Exemplification of the use of Tables XXIX to XLVIII.

Suppose *a*, *b*, *c*, *d*, *e*, *f*, *g* (Fig. 1, Plate XXXV) to represent the surface of the ground, and *h*, *k*, the formation level of a road passing through it in cutting, and let the cross section of such road be as represented in Fig. 2, having a width at formation level of 24 feet with side slopes of 1½ to 1. The prismoidal mean areas of the different sections A, B, C, D, &c., will be found in Table XLIII and the cubical contents *in feet* of each of these sections may be found and tabulated in the following manner :—

	Heights of Sections at each end.		Tabular Number.	Length of Section in feet.	Volume in Cubic Feet.
Section A	10	15	537·5	50	26,875
„ B	15	20	882·5	25	22,062·5
„ C	20	18	998·0	100	99,800
„ D	18	14	769·9	75	57,742·5
„ E	14	12	566·0	50	28,300
„ F	12	7	366·5	100	36,650
Total Cubic-*Feet* Cutting ...					271,430

Exemplification of the use of Tables XLIX to LXXX.

Let *a*, *b*, *c*, *d*, *e*, *f*, *g*, (Fig. 3, Plate XXXV) represent the longitudinal section along the centre of a road, and *h*, *k* the formation level of its embanked surface, and let the cross section of such road be as represented in Fig. 4, having a width at formation level of 18 feet with side slopes of 2 to 1. Had the requisite base (18 feet) not been one which is given in the following Tables it would have been necessary to have had recourse to the second series of Tables from LXXIII to LXXX, in the manner shown below. The prismoidal mean area of each of the sections A, B, C, D, &c., being ascertained as shown below each should be multiplied by the length of the section *in feet*, and the results obtained will be the volumes *in cubic yards* of each section :—

	Heights of Sections at each end.		Tabular Number for Slope 2 to 1 from Tables.		Prismoidal Mean Area.	Length of Section in Feet.	Volume in Cubic-yards.	Remarks.
			Mult.	Add.				
Section A ...	12	4	·2963	5·136	10·4694	100	1,046·94	To find prismoidal mean area multiply the number in column under "Mult" by the given base, and added thereto quantity shown in column "Add," thus :—
,, B ...	4	8	·2222	2·765	6·7646	25	169·11	
,, C ...	8	6	·2593	3·654	8·3214	40	332·85	
,, D ...	6	2	·1481	1·284	3·9428	60	236·98	
,, E ...	2	3	·0926	0·469	2·1358	75	160·18	
,, F ...	3	10	·2407	3·432	7·7646	100	776·46	·2963 × 18 + 5·136 = 10·4694 ·2222 × 18 + 2·765 = 6·7646 ·2593 × 18 + 3·654 = 8·3214 &c. &c. &c.
Total Cubic *Yards* Embankment ...							2722·52	

Description of Tables LXXXI to LXXXIV.

In order to take out the quantity of masonry work in a bridge or culvert having segmental arches a simple though laborious calculation is needed to ascertain (1) the area of the arch-ring, and (2) that of the segment of the circle formed by the intrados of the arch and the springing line. This latter area, multiplied, of course, by the thickness of the spandril walls, has to be deducted before the contents of the spandril walls can be accurately determined.

It will be clear then that a vast amount of labour would be saved if in those cases in which the arch-ring was of a prescribed thickness and its rise bore some well defined ratio to the span the two areas above alluded to were determined and expressed in terms *of the span itself*.

This has been done in Table LXXXI. An examination of this Table will show how that for the ordinarily adopted rises of one-third, one-fourth, one-fifth, one-sixth, and one-seventh of span, and for thicknesses of arch-ring from 6 inches to 3 feet the radius of the circle, the area of the segment, and that of the arch-ring itself have all been expressed in terms of the *span alone*. The example given at the foot of this Table will further illustrate its use, and the saving effected in labour over the ordinary method in arriving at these same results.

Tables LXXXII., LXXXIII. and LXXXIV. are based on Table LXXXI., and give *at sight* the above information for certain useful spans from 5 to 45 feet, when the rise of the arch bears one or other of the ordinarily adopted ratios above named, and is of some corresponding suitable thickness.

These Tables from LXXXI. to LXXXIV. will therefore in their own way, though perhaps not quite to the same extent, facilitate the preparation of estimates for bridges and culverts as those from XXIX. to XLVIII. do that of the earth-work in Road or Canal projects.

TABLE XXIX.—Base 18, Slopes ½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	9·153	18·66	28·53	38·69	49·16	59·99	71·14	82·64	94·52	106·7	119·2	132·0	145·1	158·7	172·5	186·7	201·2	216·0	231·2	246·7	0
1	18·50	28·18	38·17	48·51	59·18	70·14	81·48	93·19	105·2	117·5	130·2	143·1	156·5	170·2	184·2	198·5	213·1	228·2	243·5	259·1	1
2	28·18	38·01	48·16	58·67	69·49	80·64	92·19	104·0	116·2	128·6	141·5	154·7	168·2	182·0	196·2	210·6	225·5	240·7	256·2	272·0	2
3	38·17	48·16	58·50	69·14	80·13	91·52	103·2	115·2	127·5	140·1	153·2	166·5	180·2	194·2	208·5	223·2	238·2	253·5	269·2	285·2	3
4	48·51	58·67	69·14	79·97	91·20	102·7	114·5	126·6	139·1	152·0	165·2	178·7	192·5	206·6	221·2	236·0	251·2	266·7	282·5	298·7	4
5	59·18	69·49	80·13	91·20	102·5	114·2	126·2	138·5	151·2	164·2	177·5	191·2	205·2	219·5	234·2	249·2	264·5	280·2	296·1	312·6	5
6	70·14	80·64	91·52	102·7	114·2	126·0	138·1	150·7	163·5	176·7	190·2	204·4	218·2	232·7	247·5	262·7	278·2	294·0	310·2	326·7	6
7	81·48	92·19	103·2	114·5	126·2	138·1	150·5	163·2	176·2	189·5	203·2	217·2	231·5	246·2	261·2	276·5	292·1	308·2	319·1	341·2	7
8	93·19	104·0	115·2	126·6	138·5	150·7	163·2	176·0	189·2	202·6	216·5	230·7	245·2	260·0	275·2	290·6	306·5	322·7	339·2	356·0	8
9	105·2	116·2	127·5	139·1	151·2	163·5	176·2	189·2	202·5	216·2	230·2	244·5	259·2	274·2	289·5	305·2	321·2	337·5	354·2	371·1	9
10	117·5	128·6	140·1	152·0	164·2	176·7	189·5	202·6	216·2	230·0	244·2	258·7	273·5	288·6	304·2	320·0	336·2	352·6	369·5	386·7	10
11	130·2	141·5	153·2	165·2	177·5	190·2	203·2	216·5	230·2	244·2	258·5	373·2	288·1	303·5	319·2	335·2	351·5	368·1	385·2	402·5	11
12	143·1	154·7	166·5	178·7	191·2	204·0	217·2	230·7	244·5	258·7	373·2	288·0	303·2	318·7	334·5	350·6	367·1	384·0	401·2	418·7	12
13	156·5	168·2	180·2	192·5	205·2	218·2	231·5	245·2	259·2	273·5	288·1	303·2	318·5	334·2	350·2	366·5	383·2	400·2	417·5	435·2	13
14	170·2	182·0	194·2	206·6	219·5	232·7	246·2	260·0	274·2	288·6	303·5	318·7	334·2	350·0	366·1	382·7	399·5	416·7	434·2	452·0	14
15	184·2	196·2	208·5	221·2	234·2	247·5	261·2	275·2	289·5	304·2	319·2	334·5	350·2	366·1	382·5	399·2	416·2	433·5	451·2	469·1	15
16	198·5	210·6	223·2	236·0	249·2	262·7	276·5	290·6	305·2	320·0	335·2	350·6	366·5	382·7	399·2	416·0	433·2	450·7	468·5	486·7	16
17	213·1	225·5	238·2	251·2	264·5	278·2	292·1	306·5	321·2	336·2	351·5	367·1	383·2	399·5	416·2	433·2	450·5	468·1	486·2	504·5	17
18	228·2	240·7	253·5	266·7	280·2	294·0	308·2	322·7	337·5	352·6	368·1	384·0	400·2	416·7	433·5	450·7	468·1	486·0	504·2	522·7	18
19	243·5	256·2	269·2	282·5	296·1	310·2	324·5	339·2	354·2	369·5	385·2	401·2	417·5	434·2	451·2	468·5	486·2	504·2	522·5	541·2	19
20	259·2	272·0	285·2	298·7	312·6	326·7	341·2	356·0	371·1	386·7	402·5	418·7	435·2	452·0	469·1	486·7	504·5	522·7	541·2	560·0	20

TABLE XXX.—Base 18, Slopes 1 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	9·315	19·31	30·02	41·36	53·32	65·98	79·32	93·31	108·0	123 4	139·3	156·0	173·3	191·4	210·0	229·3	249·3	270·0	291·4	313·3	0
1	18·98	29·34	40 33	52·00	64·34	77·32	90·98	105·3	120·3	136·0	152·3	169·3	187·0	205·3	224·3	244·0	264·3	285·4	307·0	329·4	1
2	29·34	40·01	51·35	63·34	75·98	89·31	103·3	118·0	133·3	149·3	166·0	183·3	201·3	220·0	239·3	259·3	280·0	301·4	323·3	346·0	2
3	40·33	51·35	62·99	75·32	88·31	102·0	116·3	134·0	147·0	163·3	180·3	198·0	216·3	235·3	255·0	275·4	296·4	318·0	340·3	363·3	3
4	52·00	63·34	75·32	88·00	101·3	115·3	130·0	145·3	161·3	178·0	195·4	213·3	232·0	251·3	271·4	292·0	313·3	335·3	358·0	379·6	4
5	64·34	75·98	88·31	101·3	115·0	129·3	144·3	160·0	176·3	193·3	211·0	229·3	248·3	268·0	288·3	309·3	331·0	353·3	376·3	400·0	5
6	77·32	89·31	102·0	115·3	129·3	144·0	159·3	175·3	192·0	209·3	227·3	246·0	265·4	285·3	306·0	327·3	349·3	372·0	395·4	419·3	6
7	90·98	103·3	116·3	130·0	144·3	159·3	175·0	191·3	208·3	226·0	244·3	263·4	280·0	303·4	324·3	346·0	368·0	391·3	415·0	439·3	7
8	105·3	118·0	134·0	145·3	160·0	175·3	191·3	208·0	225·3	243·3	262·0	276·0	301·3	322·0	343·3	365·3	388·0	411·3	435·3	460·0	8
9	120·3	133·3	147·0	161·3	176·3	192·0	208·3	225·3	243·0	261·4	280·3	300·0	320·3	341·3	363·0	385·3	408·3	432·0	456·3	481·3	9
10	136·0	149·3	163·3	178·0	193·3	209·3	226·0	243·3	261·4	280·0	299·4	319·3	340·0	361·3	383·3	406·0	429·3	453·3	478·0	503·4	10
11	152·3	166·0	180·3	195·4	211·0	227·3	244·3	262·0	280·3	299·4	319·0	339·3	360·3	382·0	404·4	427·3	451·0	475·3	500·4	526·0	11
12	169·3	183·3	198·0	213·3	229·3	246·0	263·4	276·0	300·0	319·3	339·3	360·0	381·3	403·4	426·0	449·3	473·3	498·0	523·3	549·3	12
13	187·0	201·3	216·3	232·0	248·3	265·4	283·0	301·3	320·3	340·0	360·3	381·3	403·0	425·3	448·3	472·0	496·4	521·3	547·0	573·3	13
14	205·3	220·0	235·3	251·3	268·0	285·3	303·4	322·0	341·3	361·3	382·0	403·4	425·3	448·0	471·3	495·4	520·0	545·3	571·3	598·0	14
15	224·3	239·3	255·0	271·4	288·3	306·0	324·3	343·3	363·0	383·3	404·4	426·0	448 3	471·3	495·0	519·3	544·3	570·0	596·3	623·3	15
16	244·0	259·3	275·4	292·0	309·3	327·3	346·0	365·3	385·3	406·0	427·3	449·3	472·0	495·4	519·3	544·0	569·3	595·3	622·0	649·3	16
17	264·3	280·0	296·4	313·3	331·0	349·3	368·0	388·0	408·3	429·3	451·0	473·3	496·4	520·0	544·3	569·3	595·0	621·3	648·3	676·0	17
18	285·4	301·4	318·0	335·3	353·3	372·0	391·3	411·3	432·0	453·3	475·3	498·0	521·3	545·3	570·0	595·3	621·3	648·0	675·3	703·3	18
19	307·0	323·3	340·3	358·0	376·3	395·4	415·0	435·3	456·3	478·0	500·4	523·3	547·0	571·3	596·3	622·0	648·3	675·3	703·0	731·3	19
20	329·4	346·0	363·3	379·6	400·0	419·3	439·3	460·0	481·3	503·4	526·0	549·3	573·3	598·0	623·3	649·3	676·0	703·3	731·3	760·0	20

TABLE XXXI.—Base 18.—Slopes 1½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	9·504	19·98	31·53	44·00	57·50	72·00	87·47	104·0	121·5	140·0	159·5	180·0	201·5	224·0	247·5	272·0	297·5	324·0	351·5	380 0	0
1	19·49	30·53	42·52	55·50	69·49	84·48	100·5	117·5	135·5	154·5	174·5	195·5	217·5	240·5	264·5	289·5	315·5	342·5	370·5	399·5	1
2	30·53	42·00	54·51	68·01	82·48	97·98	114·5	132·0	150·5	170·0	190·5	212·0	234·5	258·0	282·5	308·0	334·5	362·0	390·5	420·0	2
3	42·52	54·51	67·49	81·48	96·47	112·5	129·5	147·5	166·5	186·5	207·5	229·5	252·5	276·5	301·5	327·5	354·5	382·5	411·5	441·5	3
4	55·50	68·01	81·48	95·98	111·5	128·0	145·5	164·0	183·5	204·0	225·5	248 0	271·5	296·0	321 5	348·0	375·5	404·0	433·5	464·0	4
5	69·49	82·48	96·47	111·5	127·5	144·5	162·5	181·5	201·5	222·5	244·5	267 5	291·5	316·5	342·5	369·5	397·5	426·5	456·5	487·5	5
6	84·48	97·98	112·5	128·0	144·5	162·0	180·5	200·0	220·5	242·0	264·5	288·0	312·5	338·0	364·5	392·0	420·5	450·0	480·5	512·0	6
7	100·5	114·5	129·5	145·5	162·5	180·5	199·5	219·5	240·5	262·5	285·5	309·5	334·5	360·5	387·5	415·5	444·5	474·5	505·5	537·5	7
8	117·5	132·0	147·5	164·0	181·5	200·0	219·5	240·0	261 5	284·0	307·5	332·0	357 5	384·0	411·5	440·0	469·5	500·0	531·5	564·0	8
9	135·5	150·5	166·5	183·5	201·5	220·5	240·5	261·5	283·5	306·5	330·5	355·5	381·5	408·5	436·5	465·5	495·5	526·5	558 5	591·5	9
10	154·5	170·0	186·5	204·0	225·5	242·0	262·5	284·0	306·5	330·0	354·5	380·0	406·5	434·0	462·5	492·0	522·5	554·0	586·5	620·0	10
11	174·5	190·5	207·5	225·5	244·5	264·5	285·5	307·5	330·5	354·5	379·5	455·0	432·5	460·5	489·5	519·5	550·5	582·5	615·5	649·5	11
12	195·5	212·0	229·5	248·0	267·5	288·0	309·5	332·0	355·5	380·0	405·0	432·0	459·5	488 0	517·5	548·0	579·5	612·0	645·5	680·0	12
13	217·5	234·5	252·5	271·5	291·5	312·5	334·5	357·5	381·5	406·5	432·5	459·5	487·5	516·5	546·5	577·5	609·5	642·5	676·5	711·5	13
14	240·5	258·0	276·5	296·0	316·5	338·0	360·5	384 0	408·5	434·0	460·5	488·0	516·5	546·0	576·5	608·0	640·5	674·0	708·5	744·0	14
15	264·5	282·5	301·5	321·5	342·5	364·5	387·5	411·5	436·5	462·5	489·5	517·5	546·5	576·5	607·5	639·5	672·5	706·5	741·5	777·5	15
16	289·5	308·0	327·5	348·0	369·5	392·0	415·5	440·0	465·5	492·0	519·5	548·0	577·5	608·0	639·5	672·0	705·5	740·0	775·5	812·0	16
17	315·5	334·5	354·5	375·5	397·5	420·5	444·5	469·5	495·5	522·5	550·5	579·5	609·5	640·5	672·5	705·5	739·5	774·5	810·5	847·5	17
18	342·5	362·0	382·5	404·0	426·5	450·0	474·5	500·0	526·5	554·0	582·5	612·0	642·5	674·0	706·5	740·0	774·5	810·0	846·5	884·0	18
19	370·5	390·5	411·5	433·5	456·5	480·5	505·5	531·5	558·5	586·5	615·5	645·5	676·5	708·5	741·5	775·5	810·5	846·5	883·5	921·5	19
20	399·5	420·0	441·5	464·0	487·5	512·0	537·5	564·0	591·5	620·0	649·5	680·0	711·5	744·0	777·5	812·0	847·5	884·0	921·5	960·0	20

TABLE XXXII.—Base 18.—Slopes 2 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	9·666	20·66	33·02	46·68	61·66	78·00	95·66	114·6	135·0	156·7	179·7	204·0	229·7	256·7	280·0	314·7	345·7	378·0	411·7	446·7	0
1	19·98	31·69	44·68	59·02	74·65	91·65	110·0	129·7	150·7	173·0	196·7	221·9	248·0	275·7	304·7	335·0	366·6	399·7	434·0	469·7	1
2	31·69	44·00	57·67	72·65	88·99	106·6	125·7	146·0	167·6	190·7	215·0	240·7	267·7	296·0	325·7	356·7	389·0	422·7	457·7	494·0	2
3	44·68	57·67	72·00	87·66	104·6	123·0	142·7	163·7	186·0	209·6	234·7	261·0	288·7	317·7	348·0	379·7	412·7	447·0	482·7	519·6	3
4	59·02	72·65	87·66	104·0	121·7	140·7	161·0	182·6	205·6	230·0	265·7	282·7	311·0	340·6	371·7	404·0	437·7	472·7	509·0	546·6	4
5	74·65	88·99	104·6	121·7	140·0	159·7	180·6	203·0	226·7	251·7	278·0	305·7	334·6	365·0	396·7	429·7	464·0	499·7	536·7	575·0	5
6	91·65	106·6	123·0	140·7	159·7	180·0	201·7	224·7	249·0	274·7	301·7	330·0	359·7	390·7	423·0	456·7	491·6	528·0	565·7	604·7	6
7	110·0	125·7	142·7	161·0	180·6	201·7	224·0	247·7	272·7	299·0	326·7	355·7	386·0	417·7	450·7	485·0	520·6	557·7	596·0	635·7	7
8	129·7	146·0	163·7	182·6	203·0	224·7	247·7	272·0	297·7	324·7	353·0	382·7	413·7	446·0	480·0	514·7	551·0	588·7	626·7	668·0	8
9	150·7	167·6	186·0	205·6	226·7	249·0	272·7	297·7	324·0	351·7	380·7	411·0	442·7	475·7	510·0	545·7	582·7	621·0	660·7	701·6	9
10	173·0	190·7	209·6	230·0	251·7	274·7	299·0	324·7	351·7	380·0	409·7	440·7	473·0	506·6	541·7	578·0	615·7	654·7	695·0	736·7	10
11	196·7	215·0	234·7	255·7	278·0	301·7	326·7	353·0	380·7	409·7	440·0	471·6	504·6	539·0	574·7	611·7	650·0	689·7	730·7	773·0	11
12	221·9	240·7	261·0	282·7	305·7	330·0	355·7	382·7	411·0	440·7	471·6	504·0	537·7	572·7	609·0	646·7	685·6	726·0	767·7	811·4	12
13	248·0	267·7	288·7	311·0	334·6	359·7	386·0	413·7	442·7	473·0	504·6	537·7	572·0	607·7	644·7	683·0	722·7	763·7	806·0	849·7	13
14	275·7	296·0	317·7	340·6	365·0	390·7	417·7	446·0	475·7	506·6	539·0	572·7	607·7	644·0	681·6	720·7	761·0	802·7	845·7	890·0	14
15	304·7	325·7	348·0	371·7	396·7	423·0	450·7	479·7	510·0	541·7	574·7	609·0	644·7	681·6	720·0	759·7	800·7	843·0	886·7	931·7	15
16	335·0	356·7	379·7	404·0	429·7	456·7	485·0	514·7	545·7	578·0	611·7	646·7	683·0	720·7	759·7	800·0	841·7	884·7	929·0	974·7	16
17	366·6	389·0	412·7	437·7	464·0	491·6	520·6	551·0	582·7	615·7	650·0	685·6	722·7	761·0	800·7	841·7	884·0	927·6	972·7	1019·0	17
18	399 7	422·7	447·0	472·7	499·7	528·0	557·7	588·7	621·0	654·7	689·7	726·0	763·7	802·7	843·0	884·7	927·6	972·0	1017·7	1064·7	18
19	434·0	457·7	482·7	509·0	536·7	565·7	596·0	626·7	660·7	695·0	730·8	767·7	806·0	845·7	886·7	929·0	972·7	1017·7	1064·0	1111·7	19
20	469·7	494·0	519·6	546·6	575·0	604·7	635·7	668·0	701·6	736·7	773·0	811·4	849·7	890·0	931·7	974·7	1019·0	1064·7	1111·7	1160·0	20

TABLE XXXIII.—Base 20.—Slopes ½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	10·15	20·65	31·54	42·69	54·16	65·99	78·14	90·64	103·5	116·7	130·2	144·0	158·1	172·7	187·5	202·7	218·2	234·0	250·2	266·7	0
1	20·49	31·18	42·17	53·51	65·18	77·14	89·48	102·2	115·2	128·5	142·1	156·1	170·5	185·2	200·2	215·5	231·1	247·2	263·5	280·2	1
2	31·18	42·01	53·16	64·66	76·49	88·64	101·2	114·0	127·2	140·6	154·5	168·7	183·2	198·0	213·2	228·6	244·5	260·7	277·2	294·0	2
3	42·17	53·16	64·50	76·14	88·13	100·5	113·2	125·2	139·5	153·1	167·2	181·5	196·2	211·2	226·5	242·2	258·3	274·5	291·2	308·1	3
4	53·51	64·66	76·14	87·97	100·2	112·7	125·5	138·6	152·1	166·0	180·2	194·7	209·5	224·6	240·2	256·0	272·2	288·6	305·5	322·6	4
5	65·18	76·49	88·13	100·2	112·5	125·2	138·1	151·5	165·2	179·2	193·5	208·2	223·1	238·5	254·2	270·2	286·5	303·1	320·1	337·5	5
6	77·14	88·64	100·5	112·7	125·2	138·0	151·1	164·7	178·5	192·7	207·2	222·0	237·2	252·7	268·5	284·7	301·1	318·0	335·2	352·7	6
7	89·48	101·2	113·2	125·5	138·1	151·1	164·5	178·2	192·1	206·5	221·1	236·2	251·5	267·2	283·2	299·5	316·1	333·2	350·5	368·2	7
8	102·2	114·0	126·2	138·6	151·5	164·7	178·2	192·0	206·2	220·6	235·5	250·7	266·2	282·0	298·2	314·6	331·5	348·7	366·2	384·0	8
9	115·2	127·2	139·5	152·1	165·2	178·5	192·1	206·2	220·5	235·2	250·2	265·5	281·1	297·2	313·5	330·2	347·2	364·5	382·1	400·1	9
10	128·5	140·6	153·1	166·0	179·2	192·7	206·5	220·6	235·2	250·0	265·2	280·7	296·5	312·6	329·2	346·0	363·2	380·6	398·5	416·7	10
11	142·1	154·5	167·2	180·2	193·5	207·2	221·1	235·5	250·2	265·2	280·5	296·2	312·1	328·5	345·2	362·2	379·5	397·1	415·2	433·5	11
12	156·1	168·7	181·5	194·7	208·2	222·0	236·2	250·7	265·5	280·7	296·2	312·0	328·2	344·7	361·5	378·6	396·1	414·0	432·2	450·7	12
13	170·5	183·2	196·2	209·5	223·1	237·2	251·5	266·2	281·1	296·5	312·1	328·2	344·5	361·2	378·2	395·5	413·2	431·2	449·5	468·1	13
14	185·2	198·0	211·2	224·6	238·5	252·7	267·2	282·0	297·2	312·6	328·5	344·7	361·2	378·0	395·1	412·7	430·5	448·6	467·2	486·0	14
15	200·2	213·2	226·5	240·2	254·2	268·5	283·2	298·2	313·5	329·2	345·2	361·5	378·2	395·1	412·5	430·2	448·2	466·5	485·2	504·1	15
16	215·5	228·6	242·2	256·0	270·2	284·7	299·5	314·6	330·2	346·0	362·2	378·6	395·5	412·7	430·2	448·0	466·1	484·6	503·5	522·7	16
17	231·1	244·5	258·2	272·2	286·5	301·1	316·1	331·5	347·2	363·2	379·5	396·1	413·2	430·5	448·2	466·1	484·5	503·1	522·2	541·5	17
18	247·2	260·7	274·5	288·6	303·1	318·0	333·2	348·7	364·5	380·6	397·1	414·0	431·2	448·6	466·5	484·6	503·1	522·0	541·2	560·6	18
19	263·5	277·2	291·2	305·5	320·1	335·2	350·5	366·2	382·1	398·5	415·2	432·2	449·5	467·1	485·2	503·5	522·2	541·2	560·5	580·1	19
20	280·2	294·0	308·1	322·6	337·5	352·7	368·2	384·0	400·1	416·7	433·5	450·7	468·1	486·0	504·1	522·7	541·5	560·6	580·1	600·0	20

TABLE XXXIV.—Base 20.—Slopes 1 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	10·26	21·33	32·94	45·36	58·32	72·09	86·40	101·2	116·9	133·4	150·4	167·9	186·3	205·5	224·9	245·4	266·2	288·1	310·2	333·4	0
1	21·06	32·40	44·28	56·97	70·47	84·24	99·09	114·5	130·4	146·9	164·4	182·2	200·9	220·3	240·3	261·1	282·4	304·3	327·0	350 4	1
2	32·40	44·01	56·43	69·39	82·89	97·47	112·3	128·0	144·4	161·5	179·0	197·4	216·3	236·0	256·2	277·3	299·0	321·3	344·2	368·0	2
3	44·28	56·43	69·12	82·35	96·39	111·0	126·4	142·3	159·0	176·3	194·4	213·0	232·5	252·4	273·0	294·3	316·4	339·1	362·3	386·4	3
4	56·97	69·39	82·35	96·12	110·4	125·3	140·9	157·4	174·4	192·0	210·3	229·2	248·9	269 5	290·2	312·1	334·3	357·2	381·0	405·3	4
5	70·47	82·89	96·39	110·4	125·0	140·4	156·3	173·1	190·3	208·4	227·1	246·2	266·2	287·0	308·3	330·2	352·9	376·4	400·4	425·0	5
6	84·24	97·47	111·0	125·3	140·4	156·1	172·3	189·3	207·1	225·4	244·3	264·1	284·3	305·4	327·0	349·4	372·3	396·1	420·4	445·2	6
7	99·09	112·3	126·4	140·9	156·3	172·3	189·0	206·3	224·4	243·0	262·4	282·4	302·9	324·3	346·4	369·1	392·3	416·3	440·9	466·3	7
8	114·5	128·0	142·3	157·4	173·1	189·3	206·3	224·1	242·5	261·4	281·1	301·3	322·4	344·0	366·4	389·3	413·1	437·4	462·2	487·9	8
9	130·4	144·4	159·0	174·4	190·3	207·1	224·4	242·5	261·1	280·3	300·2	321·0	342·4	364·2	386·9	410·4	434·4	459·0	484·4	510·3	9
10	146·9	161·5	176·3	192·0	208·4	225·4	243·0	261·4	280·3	300·0	320·2	341·3	362·9	385·3	408·2	432·0	456·3	481·4	507·1	533·2	10
11	164·4	179·0	194·4	210·3	227·1	244·3	262·4	281·1	300·2	320·2	341·0	362·3	384·2	406·9	430·4	454·4	479·0	504·4	530·3	557·0	11
12	182·2	197·4	213·0	229·2	246·2	264·1	282·4	301·3	321·0	341·3	362·3	383·9	406·3	429·3	453·1	477·4	503·5	528·1	554·3	581·3	12
13	200·9	216·3	232·5	248·9	266·2	284·3	302·9	322·4	342·4	362·9	384·2	406·3	429·0	452·2	476·3	501·1	526·2	552·4	578·9	606·4	13
14	220·3	236·0	252·4	269·5	287·0	305·4	324·3	344·0	364·2	385·3	406·9	429·3	452·2	476·0	500·3	525·4	551·1	577·3	604·3	632·1	14
15	240·3	256·2	273·0	290·2	308·3	327·0	346·4	366·4	386·9	408·2	430·4	453·1	476·3	500·3	524·9	550·3	576·4	602·9	630·4	658·3	15
16	261·1	277·3	294·3	312·1	330·2	349·4	369·1	389·3	410·4	432·0	454·4	477·4	501·1	525·4	550·3	575·9	602·4	629·4	656·9	685·3	16
17	282·4	299·0	316·4	334·3	352·9	372·3	392·3	413·1	434·4	456·3	479·0	503·5	526·2	551·1	576·4	602·4	629·1	656·4	684·4	713·1	17
18	304·3	321·3	339·1	357·2	376·4	396·1	416·3	437·4	459·0	481·4	504·4	528·1	552·4	577·3	602·9	629·4	656·4	683·9	712·3	741·4	18
19	327·0	344·2	362·3	381·0	400·4	420·4	440·9	462·2	484·4	507·1	530·3	554·3	578·9	604·3	630·4	656·9	684·4	712·3	740·9	770·3	19
20	350·5	368·0	386·4	405·3	425·0	445·2	466·3	487·9	510·3	533·2	557·0	581·3	606·4	632·1	658·3	685·3	713·1	741·4	770·3	800·0	20

TABLE XXXV.—Base 20.—Slopes $1\frac{1}{2}$ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	10·53	21·87	34·56	48·06	62·67	78·03	94·50	112·0	130·4	149·8	170·4	192·0	214·4	237·9	262·4	288·1	314·5	342·1	370·4	399·9	0
1	21·60	33·48	46·44	60·46	75·60	91·53	108·5	126·4	145·5	165·5	186·6	208·4	231·4	255·4	280·5	306·4	333·4	361·5	390·4	420·4	1
2	33·48	45·90	59·40	73 98	89·37	105 8	123·4	142·0	161·5	182·0	203·6	226·0	249·5	274·0	299·4	325·9	353·4	382·0	411·5	442·0	2
3	46·44	59·40	73·44	88·56	104·5	121·5	139·6	158·5	178·5	199·5	221·4	244·3	268·4	293·5	319·4	346·4	374·5	403·4	433·3	464·4	3
4	60·48	73·98	88·56	103·9	120·4	138·0	156·6	176·0	196·6	217·9	240·6	264·1	288·4	314·0	340·5	368·0	396·4	426·1	456·6	487·9	4
5	75·60	89·37	104·5	120·4	137·4	155·5	174·4	194·4	215·5	237·6	260·5	284·6	309·4	335·3	362·3	390·4	419·6	449·5	480·6	512·5	5
6	91·53	105·8	121·5	138·0	155·5	173·9	193·6	213·8	235·4	257·8	281·3	305·9	331·6	358·0	385·6	413·9	443·3	473·8	505·4	537·8	6
7	108·5	123·4	139·6	156·6	174·4	193·6	213·6	234·4	256 5	279·4	303·5	328·6	354·5	381·5	409·6	438·5	468·4	499·5	531·4	564·6	7
8	126·4	142·0	158·5	176·0	194·4	213·8	234·4	256·0	278·4	301·9	326·4	352·1	378·5	406·1	434·4	463·9	494·4	526·0	558·4	591·8	8
9	145·5	161·5	178·5	196·6	215·5	235·4	256·5	278·4	301·3	325·3	350·5	376·4	403·4	431·5	460·3	490·3	521·4	553·5	586·4	620·5	9
10	165·5	182·0	199·5	217·9	237·6	257·8	279·4	301·9	325·3	349·9	375·6	402·0	429·6	457·9	487·3	517·9	549·4	581·8	615·6	649·9	10
11	186·6	203·6	221·4	240·6	260·5	281·3	303·5	326·4	350·5	375 6	401·5	428·5	456·6	485·5	515·4	546·5	578·3	611·5	645·6	680·4	11
12	208·4	226·0	244·3	264·1	284·6	305·9	328·6	352·1	376·4	402·0	428·5	456·0	484·4	513·8	544·6	575·9	608·6	642·1	676·3	712·0	12
13	231·4	249·5	268·4	288·4	309·4	331·6	354·5	378·5	403·4	429·6	456·6	484·4	513·5	543·5	574·6	606·4	639·4	673·4	708·5	744·4	13
14	255·4	274·0	293·5	314·0	335·3	358·0	381·5	406·1	431·5	457·9	485·5	513·8	543·5	574·0	605·3	638·0	671·5	706·0	741·4	777·9	14
15	280·5	299·4	319·4	340·5	362·3	385·6	409·6	434·4	460·3	487·3	515·4	544·6	574·6	605·3	637·5	670·4	704·4	739·5	775·4	812·4	15
16	306·4	325 9	346·4	368·0	390·4	413·9	438·5	463·9	490·3	517·9	546·5	575·9	606·4	638·0	670·4	703·9	738·4	774·1	810·5	848·1	16
17	333·4	353·4	374·5	396·4	419·6	443·3	468·4	494·4	521·4	549·4	578·3	608·6	639·4	671·5	704·4	738·4	773·5	809·5	846·4	884·5	17
18	361·5	382·0	403·4	426·1	449·5	473·8	499·5	526·0	553·5	581·8	611·5	642·1	673·4	706·0	739·5	774·1	809·5	845·9	883·4	922·0	18
19	390·4	411·5	433·3	456·6	480·6	505·4	531·4	558·4	586·4	615·6	645·6	676·3	708·5	741·4	775·4	810·5	846·4	883·4	921·5	960·4	19
20	420·4	442·0	464·4	487·9	512·5	537·8	564·6	591·8	620·5	649·9	680·4	712 0	744·4	777·9	812·4	848·1	884·5	922·0	960·4	1000	20

TABLE XXXVI.—Base 20.—Slopes 2 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	10·80	22·68	35·91	50·76	66·69	83·97	102·6	122·6	143·9	166·6	190·6	216·0	242·7	270·5	300·0	330·7	362·6	396·1	430·6	466·6	0
1	21·87	34·56	48·60	63·99	80·75	98·55	118·0	138·5	160·6	183·9	208·7	234·6	261·9	290·5	320·8	352·1	384·7	418·8	453·9	490·6	1
2	34·56	48·06	62·64	78·57	95·85	114·7	134·7	156·1	178·7	202·8	227·9	254·6	282·7	311·8	342·6	374·8	408·0	442·5	478·7	516·0	2
3	48·60	62·64	78·03	94·77	112·6	132·0	152·5	174·7	197·9	222·7	248·7	275 9	304·6	334·5	365·8	398·5	432·5	467·9	504·6	542·7	3
4	63·99	78·57	94·77	112·0	130·7	150·7	172·0	194·7	218·7	244·1	270·5	298·6	328·0	358·6	390·7	423·9	458·7	494·6	531·9	570·5	4
5	80·73	95·85	112·6	130·7	149·8	170·6	192·5	216·0	240·6	266·8	294·0	322·6	352·6	383·9	416·6	450·6	486·0	522·7	560·8	599·9	5
6	98·55	114·7	132·0	150·7	170·6	192·0	214·6	238·7	264·1	290·5	318·6	348·0	378·5	410·7	443·9	478·7	514·6	551·9	590·8	630·7	6
7	118·0	134·7	152·5	172·0	192·5	214·6	237·9	262·7	288·6	315·9	344·5	374·8	406·1	438·7	472·8	507·9	544·6	582·7	622·1	662·6	7
8	138·5	156·1	174·7	194·7	216·0	238·7	262·7	288·1	314·5	342·6	372·1	402·6	434·7	467·9	502·7	538·6	575·9	614·5	654·7	696·1	8
9	160·6	178·7	197·9	218·7	240·6	264·1	288·6	314·5	342·1	370·7	400·7	432·0	464·7	498·7	534·1	570·5	608·6	648·0	688·8	730·6	9
10	183·9	202·8	222·7	244·1	266·8	290·5	315·9	342·6	370·7	399·9	430·6	462·5	496·0	530·5	566·7	604·0	642·6	682·6	723·9	766·8	10
11	208·7	227·9	248·7	270·5	294·0	318·6	344·5	372·1	400·7	430·6	462·0	494·6	528·7	564·0	600·7	638·5	678·0	718·7	760·6	804·1	11
12	234·6	254·6	275·9	298·6	322·6	348·0	374·8	402·6	432·0	462·5	494·6	527·8	562·7	598·6	635·8	674·7	714·7	756·0	798·7	842·7	12
13	261·9	282·7	304·6	328·0	352·6	378·5	406·1	434·7	464·7	496·0	528·7	562·7	598·0	634·8	672·6	712·0	752·8	794·6	838·1	882·6	13
14	290·5	311·8	334·5	358·6	383·9	410·7	438·7	467·9	498·7	530·5	564·0	598·6	634·8	672·0	710·6	750·6	791·9	834·6	878·6	923·9	14
15	320·8	342·6	365·8	390·7	416·6	443·9	472·8	502·7	534·1	566·7	600·7	635·8	672·6	710·6	750·1	790·6	832·7	875·9	920·7	966·6	15
16	352·1	374·8	398·5	423·9	450·6	478·7	507·9	538·6	570·5	604·0	638·5	674·7	712 0	750·6	790·6	831·9	874·5	918·5	963·9	1011·	16
17	384·7	408·0	432·5	458·7	486·0	514·6	544·6	575·9	608·6	642·6	678·0	714·7	752·8	791·9	832·7	874·5	918·0	962·5	1009·	1056·	17
18	418·8	442·5	467·9	494·6	522·7	551·9	582·7	614·5	648·0	682·6	718·7	756·0	794·6	834·6	875·9	918·5	962·5	1008·	1055·	1103·	18
19	453·9	478·7	504·6	531·6	560·8	590·8	622·1	654·7	688·8	723·9	760·6	798·7	838·1	878·6	920·7	963·9	1009·	1055·	1102·	1151·	19
20	490·6	516·0	542·7	570·5	599·9	630·7	662·6	696·1	730·6	766·8	804·1	842·7	882·6	923·9	966·6	1011·	1056·	1103·	1151·	1200·	20

TABLE XXXVII.—Base 22.—Slopes ½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	11·15	22·65	34·53	46·68	59·16	71·98	85·13	98 63	112·5	126·6	141·1	156·0	171·1	186·7	202·5	218·6	235·1	252·0	269·2	286·6	0
1	22·49	34·18	46·17	58·51	71·17	84·13	97·47	111·2	125·2	139·5	154·1	169·1	184·5	200·1	216·2	232·5	249·1	266·2	283·5	301·1	1
2	34·18	46·01	58·16	70·66	83·48	96·63	110·2	124·0	138·1	152·6	167·4	182·7	198·1	214·0	230·1	246·6	263·5	280·7	298·2	316·0	2
3	46·17	58·16	70·50	83·13	96·12	109·5	123·2	137·2	151·5	166·1	181·2	196·5	212·2	228·1	244·4	261·2	278·1	295·5	313·1	331·1	3
4	58·51	70·66	83·13	95·96	109·2	122·7	136·5	150·6	165·1	180·0	195·1	210·6	226·5	242·6	259·2	276·0	293·1	310·6	328·4	346·6	4
5	71·17	83·48	96·12	109·2	122·5	136·2	150·1	164·4	179·2	194·1	209·5	225·1	241·1	257·5	274·1	291·1	308·5	326·1	344·1	362·5	5
6	84·13	96·63	109·5	122·7	136·2	150·0	164·1	178·7	193·5	208·6	224·1	240·0	256·2	272·7	289·5	306·6	324·1	341·9	360·2	378·7	6
7	97·47	110·2	123·2	136·5	150·1	164·1	178·5	193·1	208·1	223·5	239·1	255·2	271·5	288·1	305·1	322·5	340·1	358·2	376·2	395·2	7
8	111·2	124·0	137·2	150·6	164·4	178·7	193·1	208·0	223·1	238·6	254·5	270·7	287·1	304·0	321·1	338·6	356·5	374·7	393·2	412·0	8
9	125·2	138·1	151·5	165·1	179·2	193·5	208·1	223·1	238·5	254·2	270·2	286·5	303·1	320·1	337·4	355·2	373·2	391·5	410·1	429·1	9
10	139·5	152·6	166·1	180·0	194·1	208·6	223·5	238·6	254·2	270·0	286·1	302·6	319·5	336·6	354·2	372·0	390·2	408·6	427·5	446·7	10
11	154·1	167·4	181·2	195·1	209·5	224·1	239·1	254·5	270·2	286·1	302·5	319·1	336·1	353·5	371·2	389·2	407·5	426·1	445·2	464·5	11
12	169·1	182·7	196·5	210·6	225·1	240·0	255·2	270·7	286·5	302·6	319·1	336·0	353·2	370·7	388·5	406·6	425·1	444·0	463·2	482·7	12
13	184·5	198·1	212·2	226·5	241·1	256·2	271·5	287·1	303·1	319·5	336·1	353·2	370·5	388·2	406·2	424·5	443·2	462·2	481·5	501·1	13
14	200·1	214·0	228·1	242·6	257·5	272·7	288·1	304·0	320·1	336·6	353·5	370·7	388·2	406·0	424·1	442·7	461·5	480·6	500·1	520·0	14
15	216·2	230·1	244·4	259·2	274·1	289·5	305·1	321·1	337·4	354·2	371·2	388·5	406·2	424·1	442·5	461·2	480·2	499·5	519·1	539·1	15
16	232·5	246·6	261·2	276·0	291·1	306·6	322·5	338·6	355·2	372·0	389·2	406·6	424·5	442·7	461·2	480·0	499·1	518·6	538·5	558·7	16
17	249·1	263·5	278·1	293·1	308·5	324·1	340·1	356·5	373·2	390·2	407·5	425·1	443·2	461·5	480·2	499·1	518·5	538·1	558·2	578·5	17
18	266·2	280·7	295·5	310·6	326·1	341·9	358·2	374·7	391·5	408·6	426·1	444·0	462·2	480·6	499·5	518·6	538·1	558·0	578·2	598·6	18
19	283·5	298·2	313·1	328·4	344·1	360·2	376·5	393·2	410·1	427·5	445·2	463·2	481·5	500·1	519·1	538·5	558·2	578·2	598·5	619·1	19
20	301·1	316·0	331·1	346·6	362·5	378·7	395·2	412·0	429·1	446·7	464·5	482·7	501·1	520·0	539·1	558·7	578·5	598·6	619·1	639·9	20

TABLE XXXVIII.—Base 22.—Slopes 1 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	11·31	23·30	36·02	49·36	63·31	77·98	93·31	109·3	126·0	143·3	161·3	180·0	199·3	219·3	240·0	261·3	283·3	306·0	329·3	353·3	0
1	22·98	35·34	48·33	61·99	76·33	91·31	107·0	123·3	140·3	158·0	176·3	195·3	215·0	235·3	256·3	278·0	300·3	323·3	347·0	371·3	1
2	35·34	48·01	61·34	75·33	89·96	105·3	121·3	138·0	155·3	173·3	192·0	211·3	231·3	252·0	273 3	295·3	318·0	341·3	365·3	390·0	2
3	48·33	61·34	74·98	89·32	104·3	120·0	136·3	156·0	171·0	189·3	208·3	228·0	248·3	269·3	290·9	313·3	336·3	360·0	384·3	409·3	3
4	61·99	75·33	89·32	104·0	119·3	135·3	152·0	169·3	187·3	206·0	225·3	245·3	266·0	287·3	309·3	332·0	355·3	379·3	404·0	427·6	4
5	76·33	89·96	104·3	119·3	135·0	151·3	168·3	186·0	204·3	223·3	243·0	263·3	284·3	306·0	328·3	351·3	375·0	399·3	424·3	450·0	5
6	91·31	105·3	120·0	135·3	151·3	168·0	185·3	203·3	222·0	241·3	261·3	282·0	303·3	325·3	348·0	371·3	395·3	419·9	445·4	471·3	6
7	107·0	121·3	136·3	152·0	168·3	185·3	203·0	221·3	240·3	260·0	280·3	301·3	323·0	345·3	368·3	391·9	416·3	441·3	467·0	493·3	7
8	123·3	138·0	156·0	169·3	186·0	203·3	221·3	240·0	259·3	279·3	300·0	315·9	343·3	366·0	389·3	413·3	438·0	463·3	489·3	516·0	8
9	140·3	155·3	171·0	187·3	204·3	222·0	240 3	259·3	279·0	299·3	320·3	342·0	364·3	387·3	410·9	435·3	460·3	486·0	512·3	539·3	9
10	158·0	173·3	189·3	206·0	223·3	241·3	260·0	279·3	299·3	320·0	341·3	363·3	386·0	409·3	433·3	458·0	483·3	509·3	536·0	563·3	10
11	176·3	192·0	208·3	225·3	243·0	261·3	280·3	300·0	320·3	341·3	363·0	385·3	408·3	432·0	456·3	481·3	507·0	533·3	560·3	588·0	11
12	195·3	211·3	228·0	245·3	263·3	282·0	301·3	315·9	342·0	363·3	385·3	407·9	431·3	455·3	480·0	505·3	531·3	558·0	585·3	613·3	12
13	215·0	231·3	248·3	266·0	284·3	303·3	323·0	343·3	364·3	386·0	408·3	431·3	455·0	479·3	504·3	530·0	556·4	583·3	611·0	639·3	13
14	235·3	252·0	269·3	287·3	306·0	325·3	345·3	366·0	387·3	409·3	432·0	455·3	479·3	504·0	529·3	555 4	582·0	609·3	637·3	666·0	14
15	256·3	273·3	290·9	309·3	328·3	348·0	368·3	389·3	410·9	433·3	456·3	480·0	504·3	529·3	555·0	581·3	608·3	636·0	664·3	693·3	15
16	278·0	295·3	313·3	332·0	351·3	371·3	391·9	413·3	435·3	458·0	481·3	505·3	530·0	555·4	581 3	608·0	635·3	663·3	691·9	721·3	16
17	300·3	318·0	336·3	355·3	375·0	395·3	416·3	438·0	460·3	483·3	507·0	531·3	556·4	582·0	608·3	635·3	663·0	691·3	720·3	750·0	17
18	323·3	341·3	360·0	379·3	399·3	419·9	441·3	463·3	486·0	509·3	533·3	558·0	583·3	609·3	636·0	663·3	691·3	720·0	749·3	779·3	18
19	347·0	365·3	384·3	404·0	424·3	445·4	467·0	489·3	512·3	536·0	560·3	565·3	611·0	637·3	664·3	691·9	720·3	749·3	779·0	809·3	19
20	371·3	390·0	409·3	427·6	450·0	471·3	493·3	516·0	539·3	563·3	588·0	613·3	639·3	666·0	693·3	721·3	750·0	779·3	809·3	840·0	20

TABLE XXXIX.—Base 22.—Slopes 1½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	11·50	23·98	37·53	52·00	67·50	84·00	101·5	120·0	139·5	160·0	181·5	204·0	227·5	252·0	277·5	304·0	331·5	360·0	389·5	420·0	0
1	23·49	36·53	50·52	65·50	81·49	98·47	116·5	135·5	155·5	176·5	198·5	221·4	245·5	270·5	296·5	323·5	351·4	380·5	410·5	441·5	1
2	36·53	50·00	64·50	79·73	96·47	114·0	132·5	152·0	172·5	194·0	216·4	240·0	264·5	290·0	316·5	343·9	372·5	402·0	432·5	464·0	2
3	50·52	64·50	79·49	95·47	112·4	130·5	149·5	169·5	190·5	212·5	235·5	259·5	284·5	310·5	337·5	365·5	394·5	424·5	455·5	487·4	3
4	65·50	79·73	95·47	112·0	129·5	148·0	167·5	188·0	209·5	232·0	255·5	280·0	305·5	332 0	359·5	388·0	417·5	448·0	479·5	511·9	4
5	81·49	96·47	112·4	129·5	147·5	166·5	186·5	207·5	229·5	252·5	276·5	301·5	327·4	354·5	382·5	411·5	441·5	472·5	504·4	537·5	5
6	98·47	114·0	130·5	148·0	166·5	186·0	206·5	228·0	250·5	274·0	298·5	324 0	350·5	378·0	406·5	436·0	466·4	498·0	530·5	564·0	6
7	116·5	132·5	149·5	167·5	186·5	206·5	227·5	249·5	272·5	296·5	321·5	347·5	374·5	402·5	431·5	461·4	492·4	524·5	557·5	591·5	7
8	135·5	152·0	169·5	188·0	207·5	228·0	249·5	272·0	295·5	320·0	345·5	372·0	399·5	428·0	457·5	487·9	519·5	552·0	585·5	620·0	8
9	155·5	172·5	190·5	209·5	229·5	250·5	272·5	295·5	319·5	344·5	370·5	397·5	425·5	454·5	484·5	515·5	547·5	580·5	614·5	649·5	9
10	176·5	194·0	212·5	232·0	252·5	274·0	296·5	320·0	344·5	370·0	396·5	424·0	452·5	481·9	512·5	544·0	576·5	610·0	644·5	680·0	10
11	198·5	216·4	235·5	255·5	276·5	298·5	321·5	345·5	370·5	396·5	423·5	451·5	480·5	510·5	541·5	573·5	606·5	640·5	675·5	711·5	11
12	221·4	240·0	259·5	280·0	301·5	324·0	347·5	372·0	397·5	424·0	451·5	479·9	509·5	540·0	571·5	604·0	637·5	672·0	707·5	744·0	12
13	245·5	264·5	284·5	305·5	327·4	350·5	374·5	399·5	425·5	452·5	480·5	509·5	539·5	570·5	602·5	635·5	669·5	704·5	740·5	777·5	13
14	270·5	290·0	310·5	332·0	354·5	378·0	402·5	428·0	454·5	481·9	510·5	540·0	570·5	602·0	634·5	668·0	702·5	738·0	774·5	812·0	14
15	296·5	316·5	337·5	359·5	382·5	406·5	431·5	457·5	484·5	512·5	541·5	571·5	602·5	634·5	667·5	701·5	736·5	772·5	809·5	847·5	15
16	323·5	343·9	365·5	388·0	411·5	436·0	461·4	487·9	515·5	544·0	573·5	604·0	635·5	668·0	701·5	736·0	771·5	808·0	845·5	884·0	16
17	351·4	372·5	394·5	417·5	441·5	466·4	492·4	519·5	547·5	576·5	606·5	637·5	669·5	702·5	736·5	771·5	807·5	844·5	882·5	921·5	17
18	380·5	402·0	424·5	448·0	472·5	498·0	524·5	552·0	580·5	610·0	640·5	672·0	704·5	738·0	772·5	808·0	844·5	882·0	920·5	960·0	18
19	410·5	432·5	455·5	479·5	504·4	530·5	557·5	585·5	614·5	644·5	675·5	707·5	740·5	774·5	809·5	845·5	882·5	920·5	959·5	999·5	19
20	441·5	464·0	487·4	511·9	537·5	564·0	591·5	620·0	649·5	680·0	711·5	744·0	777·5	812·0	847·5	884·0	921·5	960·0	999·5	1040·	20

TABLE XL.—Base 22.—Slopes 2 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	11·66	24·65	39·01	54·67	71·66	89·99	109·6	130·6	153·0	176·7	201·7	228·0	255·6	284·7	315·0	346·6	379·6	414·0	449·7	486·7	0
1	23·98	37·69	52·68	69·01	86·64	105·6	125·9	147·7	170·7	195·0	220·6	247·9	276·0	305·7	336·7	369·0	402·6	437·7	474·0	511·6	1
2	37·69	52·00	67·66	84·64	103·0	122·6	143·7	166·0	189·6	214·6	241·0	268·7	297·7	328·0	359·6	392·6	427·0	462·7	499·7	538·0	2
3	52·68	67·66	84·00	101·6	120·6	141·0	162·7	185·6	210·0	235·6	262·7	291·0	320·6	351·6	384·0	417·7	452·6	489·0	526·6	565·6	3
4	69·01	84·64	101·6	120·0	139·7	160·7	183·0	206·6	231·6	258·0	285·7	314·6	345·0	376·6	409·7	444·0	479·6	516·6	555·0	594·6	4
5	86·64	103·0	120·6	139·7	160·0	181·6	204·6	229·0	254·7	281·7	310·0	339·6	370·6	403·0	436·7	471·7	508·0	545·6	584·6	625·0	5
6	105·6	122·6	141·0	160·7	181·6	204·0	227·6	252·7	279·0	306·7	335·6	365·9	397·7	430·6	465·0	500·6	537·6	576·0	615·7	656·7	6
7	125·9	143·7	162·7	183·0	204·6	227·6	252·0	277·7	304·6	333·0	362·6	393·7	426·0	459·6	494·6	530·9	568·6	607·7	648·0	689·7	7
8	147·7	166·0	185·6	206·6	229·0	252·7	277·7	304·0	331·6	360·6	391·0	422·6	455·6	490·0	525·6	562·6	601·0	640·7	681·7	724·0	8
9	170·7	189·6	210·0	231·6	254·7	279·0	304·6	331·6	360·0	389·7	420·7	453·0	486·6	521·6	558·0	595·7	634·7	675·0	716·7	759·6	9
10	195·0	214·6	235·6	258·0	281·7	306·7	333·0	360·6	389·7	420·0	451·6	484·6	519·0	554·6	591·7	630·0	669·6	710·7	753·0	796·7	10
11	220·6	241·0	262·7	285·7	310·0	335·6	362·6	391·0	420·7	451·6	484·0	517·6	552·6	589·0	626·7	665·6	706·0	747·7	790·7	835·0	11
12	247·9	268·7	291·0	314·6	339·6	365·9	393·7	422·6	453·0	484·6	517·6	552·0	587·7	624·7	663·0	702·6	743·6	786·0	829·7	874·7	12
13	276·0	297·7	320·6	345·0	370·6	397·7	426·0	455·6	486·6	519·0	552·6	587·7	624·0	661·7	700·6	741·0	782·7	825·7	870·0	915·6	13
14	305·7	328·0	351·6	376·6	403·0	430·6	459·6	490·0	521·6	554·6	589·0	624·7	661·7	700·0	739·6	780·7	823·0	866·7	911·6	958·0	14
15	336·7	359·6	384·0	409·7	436·7	465·0	494·6	525·6	558·0	591·7	626·7	663·0	700·6	739·6	780·0	821·7	864·7	909·0	954·6	1002·	15
16	369·0	392·6	417·7	444·0	471·7	500·6	530·9	562·6	595·7	630·0	665·6	702·6	741·0	780 7	821·7	864·0	907·6	952·6	999·0	1047·	16
17	402·6	427·0	452·6	479·6	508·0	537·6	568·6	601·0	634·7	669·6	706·0	743·6	782·7	823·0	864·7	907·6	952·0	997·6	1045·	1093·	17
18	437·7	462·7	489·0	516·6	545·6	576·0	607·7	640·7	675·0	710·7	747·7	786·0	825·7	866·7	909·0	952·6	997·6	1044·	1092·	1141·	18
19	474·0	499·7	526·6	555·0	584·6	615·7	648·0	681·7	716·7	753·0	790·7	829·7	870·0	911·6	954·6	999·0	1045·	1092·	1140·	1190·	19
20	511·6	538·0	565·6	594·6	625·0	656·7	689·7	724·0	759·6	796·7	835·0	874·7	915·6	958·0	1002·	1047·	1093·	1141·	1190·	1240·	20

TABLE XLI.—Base 24.—Slopes ½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	12·15	24·65	37·53	50·68	64·15	77·98	92·12	106·6	121·5	136·6	152·1	168·0	184·1	200·7	217·5	234·7	252·1	270·0	288·2	306·7	0
1	24·49	37·18	50·17	63·50	77·17	91·12	105·5	120·2	135·2	150·5	166·1	182·1	198·5	215·2	232·2	249·5	267·1	285·2	303·5	322·2	1
2	37·18	50·00	63·15	76·65	90·48	104·6	119·2	134·0	149·1	164·6	180·4	196·7	213·2	230·0	247·1	264·6	282·5	300·7	319·2	338·0	2
3	50·17	63·15	76·49	90·13	104·1	118·5	133·2	148·1	163·4	179·1	195·2	211·5	228·2	245·2	262·5	280·2	298·2	316·5	335·1	354·1	3
4	63·50	76·65	90·13	103·9	118·2	132·6	147·5	162·6	178·1	194·0	210·2	226·7	243·5	260·6	278·2	296·0	314·1	332·6	351·5	370·6	4
5	77·17	90·48	104·1	118·2	132·5	147·1	162·1	177·4	193·2	209·2	225·5	242·2	259·1	276·5	294·2	312·1	330·5	349·1	368·1	387·5	5
6	91·12	104·6	118·5	132·6	147·1	162·0	177·1	192·7	208·5	224·7	241·2	258·0	275·2	292·7	310·5	328·6	347·1	365·9	385·2	404·7	6
7	105·5	119·2	133·2	147·5	162·1	177·1	192·5	208·2	224·1	240·5	257·1	274·2	291·5	309·1	327·1	345·5	364·1	383·2	402·5	422·2	7
8	120·2	134·0	148·1	162·6	177·4	192·7	208·2	224·0	240·2	256·6	273·5	290·7	308·1	326·0	344·1	362·6	381·5	400·7	420·2	440·0	8
9	135·2	149·1	163·4	178·1	193·2	208·5	224·1	240·2	256·5	273·2	290·2	307·5	325·1	343·1	361·4	380·2	399·2	418·5	438·1	458·1	9
10	150·5	164·6	179·1	194·0	209·2	224·7	240·5	256·6	273·2	290·0	307·1	324·6	342·5	360·6	379·2	398·0	417·2	436·6	456·5	476·7	10
11	166·1	180·4	195·2	210·2	225·5	241·2	257·1	273·5	290·2	307·1	324·5	342·1	360·1	378·5	397·2	416·2	435·5	455·1	475·2	495·5	11
12	182·1	196·7	211·5	226·7	242·2	258·0	274·2	290·7	307·5	324·6	342·1	360·0	378·2	396·7	415·5	434·6	454·1	474·0	494·2	514·7	12
13	198·5	213·2	228·2	243·5	259·1	275·2	291·5	308·1	325·1	342·5	360·1	378·2	396·5	415·2	434·2	453·5	473·2	493·2	513·5	534·1	13
14	215·2	230·0	245·2	260·6	276·5	292·7	309·1	326·0	343·1	360·6	378·5	396·7	415·2	434·0	453·1	472·6	492·5	512·6	533·1	553·9	14
15	232·2	247·1	262·5	278·2	294·2	310·5	327·1	344·1	361·4	379·2	397·2	415·5	434·2	453·1	472·5	492·2	512·2	532·5	553·1	574·1	15
16	249·5	264·6	280·2	296·0	312·1	328·6	345·5	362·6	380·2	398·0	416·2	434·6	453·5	472·6	492·2	512·0	532·1	552·6	573·4	594·7	16
17	267·1	282·5	298·2	314·1	330·5	347·1	364·1	381·5	399·2	417·2	435·5	454·1	473·2	492·5	512·2	532·1	552·5	573·1	594·2	615·5	17
18	285·2	300·7	316·5	332·6	349·1	365·9	383·2	400·7	418·5	436·6	455·1	474·0	493·2	512·6	532·5	552·6	573·1	594·0	615·2	636·6	18
19	303·5	319·2	335·1	351·5	368·1	385·2	402·5	420·2	438·1	456·5	475·2	494·2	513·5	533·1	553·1	573·4	594·2	615·2	636·5	658·1	19
20	322·2	338·0	354·1	370·6	387·5	404·7	422·2	440·0	458·1	476·7	495·5	514·7	534·1	553·9	574·1	594·7	615·5	636·6	658·1	679·9	20

TABLE XLII.—Base 24.—Slopes 1 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	12·31	25·30	39·01	53·35	68·31	83·97	100·3	117·3	135·0	153·3	172·3	192·0	212·3	233·4	255·0	277·3	300·3	324·0	348·3	373·3	0
1	24·97	38·34	52·33	66·99	82·32	98·31	115·0	132·3	150·3	169·0	188·3	208·3	229·0	250·3	272·3	295·0	318·3	342·4	367·0	392·3	1
2	38·34	52·00	66·34	81·32	96·96	113·3	130·3	148·0	166·3	185·3	204·9	225·3	246·3	268·0	290·3	313·3	337·0	361·3	386·3	412·0	2
3	52·33	66·34	80·97	96·31	112·3	129·0	146·3	167·0	182·9	202·3	222·3	243·0	264·3	286·3	309·0	332·3	356·3	381·0	406·3	432·3	3
4	66·99	81·32	96·31	112·0	128·3	145·3	163·0	181·3	200·3	220·0	240·3	261·3	283·0	305·3	328 3	352·0	376·3	401·3	427·0	451·6	4
5	82·32	96·96	112·3	128·3	145·0	162·3	180·3	199·0	218·3	238·3	259·0	280·3	302·3	325·0	348·3	372·3	397·0	422·3	448·3	475·0	5
6	98·31	113·3	129·0	145·3	162·3	179·9	198·3	217·3	237·0	257 3	278·3	300·0	322·3	345 3	369·0	393·3	418·3	444·0	470·4	497·3	6
7	115·0	130·3	146·3	163·0	180·3	198·3	217·0	236·3	256·3	277·0	298·3	320·3	343·0	366·3	390·3	415·0	440·3	466·3	493·0	520 3	7
8	132·3	148·0	167·0	181·3	199·0	217·3	236·3	256·0	276·3	297·3	319·0	335·9	364·3	388·0	412·3	437·3	463·0	489·3	516·3	544·0	8
9	150·3	166·3	182·9	200·3	218·3	237·0	256·3	276·3	297·0	318·3	340·3	363·0	386·3	410·3	434·9	460·3	486·3	513·0	540·3	568·3	9
10	169·0	185·3	202·3	220·0	238·3	257·3	277·0	297·3	318·3	340·0	362·3	385·3	409·0	433·3	458 3	484·0	510·3	537·3	565·0	593·3	10
11	188·3	204·9	222·3	240·3	259·0	278·3	298·3	319·0	340·3	362·3	385·0	408·3	432·3	457·0	482·3	508·3	535·0	562·3	590·3	619·0	11
12	208·3	225·3	243·0	261·3	280·3	300·0	320·3	335·9	363·0	385·3	408·3	431·9	456·3	481·3	507·0	533·3	560·3	588·0	616·3	645·3	12
13	229·0	246·3	264·3	283·0	302·3	322·3	343·0	364·3	386·3	409·0	432·3	456·3	481·0	506·3	532·3	559·0	586·3	614·3	643·0	672·3	13
14	250·3	268·0	286·3	305·3	325·0	345·3	366·3	388·0	410·3	433·3	457·0	481·3	506·3	532·0	558·3	585·4	613·0	641·3	670·3	700·0	14
15	272·3	290·3	309·0	328·3	348·3	369·0	390·3	412·3	434·9	458·3	482·3	507·0	532·3	558·3	585·0	612·3	640·3	669·0	698·3	728·3	15
16	295·0	313·3	332·3	352·0	372·3	393·3	415·0	437·3	460·3	484·0	508·3	533·3	559·0	585·4	612·3	640·0	668·3	697·3	726·9	757·3	16
17	318·3	337·0	356·3	376·3	397·0	418·3	440·3	463·0	486·3	510·3	535·0	560·3	586·3	613·0	640·3	668·3	697·0	726·3	756·3	787·0	17
18	342·4	361·3	381·0	401·3	422·3	444·0	466·3	489·3	513·0	537·3	562·3	588·0	614·3	641·3	669·0	697·3	726·3	756·0	786·3	817·3	18
19	367·0	386·3	406·3	427·0	448·3	470·4	493·0	516·3	540·3	565·0	590·3	616·3	643·0	670·3	698·3	726·9	756·3	786·3	817·0	848·3	19
20	392·3	412·0	432·3	451·6	475·0	497·3	520·3	544·0	568·3	593·3	619·0	645·3	672·3	700·0	728·3	757·3	787·0	817·3	848·3	879·9	20

TABLE XLIII.—Base 24.—Slopes $1\frac{1}{2}$ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	12·50	25·97	40·53	55·99	72·49	89·99	108·4	127·9	148·5	170·0	192·5	216·0	240·5	266·0	292·5	320·0	348·5	378·0	408·5	440·0	0
1	25·49	39·53	54·51	70·50	87·48	105·5	124·5	144·5	165·5	187·5	210·5	234·4	259·5	285·5	312·5	340·5	369·5	399·5	430·5	462·5	1
2	39·53	54·00	69·50	85·99	103·5	121·9	141·5	162·0	183·5	205·9	229·4	254·0	279·5	306·0	333·5	362·0	391·5	422·0	453·5	486·0	2
3	54·51	69·50	85·48	102·5	120·4	139·5	159·5	180·5	202·5	225·4	249·5	274·5	300·5	327·5	355·5	384·5	414·5	445·5	477·5	510·5	3
4	70·50	85·99	102·5	120·0	138·5	158·0	178·5	200·0	222·4	246·0	270·5	296·0	322·5	350·0	378·5	408·0	438·5	470·0	502·5	535·9	4
5	87·48	103·5	120·4	138·5	157·5	177·5	198·5	220·4	243·5	267·5	292·5	318·5	345·5	373·5	402·5	432·5	463·5	495·5	528·4	562·5	5
6	105·5	121·9	139·5	158·0	177·5	198·0	219·4	242·0	265·5	290·0	315·5	342·0	369·5	398·0	427·5	458·0	489·4	522·0	555·5	590·0	6
7	124·5	141·5	159·5	178·5	198·5	219·4	241·5	264·5	288·5	313·5	339·5	366·5	394·5	423·5	453·5	484·5	516·4	549·5	583·5	618·5	7
8	144·5	162·0	180·5	200·0	220·4	242·0	264·5	288·0	312·5	338·0	364·5	392·0	420·5	450·0	480·5	511·9	544·5	578·0	612·5	648·0	8
9	165·5	183·5	202·5	222·4	243·5	265·5	288·5	312·5	337·5	363·5	390·5	418·5	447·5	477·5	508·5	540·5	573·5	607·5	642·5	678·5	9
10	187·5	205·9	225·4	246·0	267·5	290·0	313·5	338·0	363·5	390·0	417·5	446·0	475·5	505·9	537·5	570·0	603·5	638·0	673·5	710·0	10
11	210·5	229·4	249·5	270·5	292·5	315·5	339·5	364·5	390·5	417·5	445·5	474·5	504·5	535·5	567·5	600·5	634·5	669·5	705·5	742·5	11
12	234·4	254·0	274·5	296·0	318·5	342·0	366·5	392·0	418·5	446·0	474·5	503·9	534·5	566·0	598·5	632·0	666·5	702·0	738·5	776·0	12
13	259·5	279·5	300·5	322·5	345·5	369·5	394·5	420·5	447·5	475·5	504·5	534·5	565·5	597·5	630·5	664·5	699·5	735·5	772·5	810·5	13
14	285·5	306·0	327·5	350·0	373·5	398·0	423·5	450·0	477·5	505·9	535·5	566·0	597·5	630·0	663·5	698·0	733·5	769·9	807·5	846·0	14
15	312·5	333·5	355·5	378·5	402·5	427·5	453·5	480·5	508·5	537·5	567·5	598·5	630·5	663·5	697·5	732·5	768·5	805·5	843·5	882·5	15
16	340·5	362·0	384·5	408·0	432·5	458·0	484·5	511·9	540·5	570·0	600·5	632·0	664·5	698·0	732·5	768·0	804·5	842·0	880·5	920·0	16
17	369·5	391·5	414·5	438·5	463·5	489·4	516·4	544·5	573·5	603·5	634·5	666·5	699·5	733·5	768·5	804·5	841·5	879·5	918·5	958·5	17
18	399·5	422·0	445·5	470·0	495·5	522·0	549·5	578·0	607·5	638·0	669·5	702·0	735·5	769·9	805·5	842·0	879·5	918·0	957·5	998·0	18
19	430·5	453·5	477·5	502·5	528·4	555·5	583·5	612·5	642·5	673·5	705·5	738·5	772·5	807·5	843·5	880·5	918·5	957·5	997·5	1038·	19
20	462·5	486·0	510·5	535·9	562·5	590·0	618·5	648·0	678·5	710·0	742·5	776·0	810·5	846·0	882·5	920·0	958·5	998·0	1038·	1080·	20

TABLE XLIV.—Base 24.—Slopes 2 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	12·66	26·65	42·01	58·67	76·65	95·98	116·6	138·6	162·0	186·6	212·6	240·0	268·6	298·7	330·0	362·7	396·6	432·0	468·7	506·7	0
1	25·97	40·69	56·67	74·01	92·64	112·6	133·9	156·6	180·6	206·0	232·6	260·9	290·0	320·7	352·7	386·0	420·6	456·7	494·0	532·6	1
2	40·69	56·00	72·66	90·64	110·0	130·6	152·6	176·0	200·6	226·6	254·0	282·7	312·7	344·0	376·6	410·6	446·0	482·7	520·7	560·0	2
3	56·67	72·66	89·99	108·6	128·6	150·0	172·7	196·6	222·0	248·6	276·7	306·0	336·7	368·6	402·0	436·7	472·7	510·0	548·6	588·6	3
4	74·01	90·64	108·6	127·9	148·7	170·7	194·0	218·6	244·6	272·0	300·7	330·7	362·0	394·6	428·7	464·0	500·7	538·6	578·0	618·6	4
5	92·64	110·0	128·6	148·7	170·0	192·6	216·6	241·9	268·7	296·7	326·0	356·6	388·6	422·0	456·7	492·7	530·0	568·5	608·6	650·0	5
6	112·6	130·6	150·0	170·7	192·6	216·0	240·6	266·7	294·0	322·7	352·6	384·0	416·7	450·6	486·0	522·6	560·6	600·0	640·7	682·7	6
7	133·9	152·6	172·7	194·0	216·6	240·6	266·0	292·7	320·6	350·0	380·6	412·7	446·0	480·6	516·6	553·9	592·6	632·7	674·0	716·7	7
8	156·6	176·0	196·6	218·6	241·9	266·7	292·7	320·0	348·6	378·6	410·0	442·7	476·6	512·0	548·6	586·6	626·0	674·0	708·7	752·0	8
9	180·6	200·6	222·0	244·6	268·7	294·0	320·6	348·6	378·0	408·7	440·7	474·0	508·6	544·6	581·9	620·7	660·7	702·0	744·7	788·6	9
10	206·0	226·6	248·6	272·0	296·7	322·7	350·0	378·6	408·7	440·0	472·7	506·6	542·0	578·6	616·7	656·0	696·6	738·7	782·0	826·7	10
11	232·6	254·0	276·7	300·7	326·0	352·6	380·6	410·0	440·7	472·7	506·0	540·6	576·6	614·0	652·7	692·6	734·0	776·6	820·7	866·0	11
12	260·9	282·7	306·0	330·7	356·6	384·0	412·7	442·7	474·0	506·6	540·6	576·0	612·7	650·7	690·0	730·6	772·6	816·0	860·7	906·7	12
13	290·0	312·7	336·7	362·0	388·6	416·7	446·0	476·6	508·6	542·0	576·6	612·7	650·0	688·7	728·6	770·0	812·1	856·7	902·0	948·6	13
14	320·7	344·0	368·6	394·6	422·0	450·6	480·6	512·0	544·6	578·6	614·0	650·7	688·7	728·0	768·6	810·7	854·0	898·7	944·6	992·0	14
15	352·7	376·6	402·0	428·7	453·7	486·0	516·6	548·6	581·9	616·7	652·7	690·0	728·6	768·6	810·0	852·7	896·7	942·0	988·6	1037·	15
16	386·0	410·6	436·7	464·0	492·7	522·6	553·9	586·6	620·7	656·0	692·6	730·6	770·0	810·7	852·7	896·0	940·6	986·6	1034·	1083·	16
17	420·6	446·0	472·7	500·7	530·0	560·6	592·6	626·0	660·7	696·6	734·0	772·6	812·7	854·0	896·7	940·6	985·9	1033·	1081·	1130·	17
18	456·7	482·7	510·0	538·6	568·6	600·0	632·7	674·0	702·0	738·7	776·6	816·0	856·7	898·7	942·0	986·6	1033·	1080·	1129·	1179·	18
19	494·0	520·7	548·6	578·0	608·6	640·7	674·0	708·7	744·7	782·0	820·7	860·7	902·0	944·6	988·6	1034·	1081·	1129·	1178·	1229·	19
20	532·6	560·0	588·6	618·6	650·0	682·7	716·7	752·0	788·6	826·7	866·0	906·7	948·6	992·0	1037·	1083·	1130·	1179·	1229·	1280·	20

TABLE XLV.—Base 26.—Slopes ½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	13·15	26·65	40·53	54·67	69·15	83·97	99·12	114·6	130·5	146·7	163·2	180·0	197·1	214·7	232·5	250·6	269·1	287·9	307·2	326·7	0
1	26·49	40·18	54·16	68·50	83·16	98·12	113·4	129·2	145·2	161·5	178·1	195·1	212·5	230·1	248·1	266·5	285·1	304·2	323·5	343·2	1
2	40·18	54·00	68·15	82·65	97·47	112·6	128·2	144·0	160·2	176·6	193·4	210·7	228·1	246·0	264·1	282·6	301·5	320·7	340·2	360·0	2
3	54·16	68·15	82·48	97·12	112·1	127·5	143·2	159·2	175·5	192·1	209·2	226·5	244·2	262·1	280·4	299·2	318·2	337·5	357·1	377·1	3
4	68·50	82·65	97·12	111·9	127·2	142·7	158·5	174·6	191·1	208·0	225·1	242·6	260·5	278·6	297·2	316·0	335·1	354·6	374·5	394·6	4
5	83·16	97·47	112·1	127·2	142·5	158·2	174·1	190·4	207·2	224·1	241·5	259·1	277·1	295·5	314·2	333·1	352·5	372·1	392·1	412·5	5
6	98·12	112·6	127·5	142·7	158·2	174·0	190·1	206·7	223·5	240·6	258·1	276·0	294·2	312·7	331·5	350·6	370·1	390·0	410·2	430·7	6
7	113·4	128·2	143·2	158·5	174·1	190·1	206·5	223·1	240·1	257·5	275·1	293·2	311·5	330·1	349·2	368·5	388·1	408·2	428·5	449·2	7
8	129·2	144·0	159·2	174·6	190·4	206·7	223·1	240·0	257·1	274·6	292·5	310·7	329·1	348·0	367·1	386·6	406·5	426·7	447·2	468·0	8
9	145·2	160·2	175·5	191·1	207·2	223·5	240·1	257·1	274·4	292·2	310·2	328·5	347·1	366·1	385·4	405·2	425·2	445·5	466·1	487·1	9
10	161·5	176·6	192·1	208·0	224·1	240·6	257·5	274·6	292·2	310·0	328·1	346·6	365·5	384·6	404·2	424·0	444·2	464·6	485·5	506·7	10
11	178·1	193·4	209·2	225·1	241·5	258·1	275·1	292·5	310·2	328·1	346·5	365·1	384·1	403·5	423·2	443·2	463·5	484·1	505·2	526·5	11
12	195·1	210·7	226·5	242·6	259·1	276·0	293·2	310·7	328·5	346·6	365·1	384·0	403·2	422·7	442·5	462·6	483·1	504·0	525·2	546·7	12
13	212·5	228·1	244·2	260·5	277·1	294·2	311·5	329·1	347·1	365·5	384·1	403·2	422·5	442·2	462·1	482·5	503·2	524·2	545·5	567·1	13
14	230·1	246·0	262·1	278·6	295·5	312·7	330·1	348·0	366·1	384·6	403·5	422·7	442·2	462·0	482·1	502·7	523·5	544·6	566·1	587·9	14
15	248·1	264·1	280·4	297·2	314·2	331·5	349·2	367·1	385·4	404·2	423·2	442·5	462·1	482·1	502·5	523·2	544·1	565·5	587·1	609·1	15
16	266·5	282·6	299·2	316·0	333·1	350·6	368·5	386·6	405·2	424·0	443·2	462·6	482·5	502·7	523·2	544·0	565·1	586·6	608·4	630·7	16
17	285·1	301·5	318·2	335·1	352·5	370·1	388·1	406·5	425·2	444·2	463·5	483·1	503·2	523·5	544·1	565·1	586·5	608·1	630·2	652·5	17
18	304·2	320·7	337·5	354·6	372·1	390·0	408·2	426·7	445·5	464·6	484·1	504·0	524·2	544·6	565·5	586·6	608·1	630·0	652·2	674·6	18
19	323·5	340·2	357·1	374·5	392·1	410·2	428·5	447·2	466·1	485·5	505·2	525·2	545·5	566·1	587·1	608·4	630·2	652·2	674·5	697·1	19
20	343·2	360·0	377·1	394·6	412·5	430·7	449·2	468·0	487·1	506·7	526·5	546·7	567·1	587·9	609·1	630·7	652·5	674·6	697·1	719·9	20

TABLE XLVI.—Base 26.—Slopes 1 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	13·31	27·30	42·01	57·35	73·30	89·96	107·3	125·3	144·0	163·3	183·3	204·0	225·3	247·3	270·0	293·3	317·3	341·9	367·4	393·3	0
1	26·97	41·34	56·32	71·98	88·32	105·3	122·9	141·3	160·3	180·0	200·3	221·3	243·0	265·3	288·3	311·9	336·3	361·4	387·0	413·3	1
2	41·34	56·00	71·33	87·32	103·9	121·3	139·3	158·0	177·3	197·3	218·0	239·3	261·3	284·0	307·3	331·3	356·0	381·3	407·3	434·0	2
3	56·32	71·33	86·97	103·3	120·3	138·0	156·3	178·0	195·0	215·3	236·3	258·0	280·3	303·3	326·9	351·3	376·3	402·0	428·3	455·3	3
4	71·98	87·32	103·3	120·0	137·3	155·3	174·0	193·3	213·3	234·0	255·3	277·3	300·0	323·3	347·3	372·0	397·3	423·3	450·0	475·6	4
5	88·32	103·9	120·3	137·3	155·0	173·3	192·3	212·0	232·3	253·3	275·0	297·3	320·3	344·0	368·3	393·3	419·0	445·3	472·3	500·0	5
6	105·3	121·3	138·0	155·3	173·3	192·0	211·3	231·3	252·0	273·3	295·3	317·9	341·4	365·3	390·0	415·3	441·3	468·0	495·4	523·3	6
7	122·9	139·3	156·3	174·0	192·3	211·3	231·0	251·3	272·3	294·0	316·3	339·4	363·0	387·3	412·3	438·0	464·3	491·3	519·0	547·3	7
8	141·3	158·0	178·0	193·3	212·0	231·3	251·3	272·0	293·3	315·3	338·0	355·9	385·3	410·0	435·3	461·3	488·0	515·3	543·3	572·0	8
9	160·3	177·3	195·0	213·3	232·3	252·0	272·3	293·3	314·9	337·4	360·3	384·0	408·3	433·3	458·9	485·3	512·3	540·0	568·3	597·3	9
10	180·0	197·3	215·3	234·0	253·3	273·3	294·0	315·3	337·4	360·0	383·3	407·3	432·0	457·3	483·3	510·0	537·3	565·3	594·0	623·3	10
11	200·3	218·0	236·3	255·3	275·0	295·3	316·3	338·0	360·3	383·3	407·0	431·3	456·3	482·0	508·3	535·3	563·0	591·3	620·3	650·0	11
12	221·3	239·3	258·0	277·3	297·3	317·9	339·4	355·9	384·0	407·3	431·3	455·9	481·3	507·3	534·0	561·3	589·3	618·0	647·3	677·3	12
13	243·0	261·3	280·3	300·0	320·3	341·4	363·0	385·3	408·3	432·0	456·3	481·3	507·0	533·3	560·3	588·0	616·3	645·3	675·0	705·3	13
14	265·3	284·0	303·3	323·3	344·0	365·3	387·3	410·0	433·3	457·3	482·0	507·3	533·3	560·0	587·3	615·3	644·0	673·3	703·3	734·0	14
15	288·3	307·3	326·9	347·3	368·3	390·0	412·3	435·3	458·9	483·3	508·3	534·0	560·3	587·3	615·0	643·3	672·3	702·0	732·3	763·3	15
16	311·9	331·3	351·3	372·0	393·3	415·3	438·0	461·3	485·3	510·0	535·3	561·3	588·0	615·3	643·3	672·0	701·3	731·3	761·9	793·3	16
17	336·3	356·0	376·3	397·3	419·0	441·3	464·3	488·0	512·3	537·3	563·0	589·3	616·3	644·0	672·3	701·3	731·0	761·3	792·3	824·0	17
18	361·4	381·3	402·0	423·3	445·3	468·0	491·3	515·3	540·0	565·3	591·3	618·0	645·3	673·3	702·0	731·3	761·3	792·0	823·3	855·3	18
19	387·0	407·3	428·3	450·0	472·3	495·4	519·0	543·3	568·3	594·0	620·3	647·3	675·0	703·3	732·3	761·9	792·3	823·3	855·0	887·3	19
20	413·3	434·0	455·3	475·6	500·0	523·3	547·3	572·0	597·3	623·3	650·0	677·3	705·3	734·0	763·3	793·3	824·0	855·3	887·3	920·0	20

TABLE XLVII—Base 26.—Slopes 1½ to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	13·50	27·97	43·52	59·99	77·49	95·98	115·4	135·9	157·5	180·0	203·5	288·0	253·5	280·0	307·5	336·0	365·5	395·9	427·5	460·0	0
1	27·51	42·52	58·51	75·49	93·47	112·4	132·5	153·5	175·5	198·5	222·5	247·4	273·5	300·5	328·5	357·5	387·4	418·5	450·5	483·5	1
2	42·52	58·00	74·49	91·99	110·4	129·9	150·5	172·0	194·5	218·0	242·5	268·0	294·5	322·0	350·5	379·9	410·5	442·0	474·5	508·0	2
3	58·51	74·49	91·48	109·4	128·4	148·5	169·5	191·5	214·5	238·5	263·5	289·5	316·5	344·5	373·5	403·5	434·5	466·5	499·5	533·5	3
4	75·49	91·99	109·4	127·9	147·5	168·0	189·5	212·0	235·5	260·0	285·5	312·0	339·5	367·9	397·5	428·0	459·5	492·0	525·5	559·9	4
5	93·47	110·4	128·4	147·5	167·5	188·5	210·5	233·5	257·5	282·5	308·5	335·5	363·4	392·5	422·5	453·5	485·5	518·5	552·4	557·5	5
6	112·4	129·9	148·5	168·0	188·5	210·0	232·5	256·0	280·5	306·0	332·5	360·0	388·5	418·0	448·5	480·0	512·5	546·0	580·5	616·0	6
7	132·5	150·5	169·5	189·5	210·5	232·5	255·5	279·5	304·5	330·5	357·4	385·5	414·5	444·5	475·5	507·5	540·4	574·5	609·5	645·5	7
8	153·5	172·0	191·5	212·0	233·5	256·0	279·5	304·0	329·5	356·0	383·5	412·0	441·5	472·0	503·5	535·9	569·5	604·0	639·5	676·0	8
9	175·5	194·5	214·5	235·5	257·5	280·5	304·5	329·5	355·4	382·5	410·5	439·5	469·5	500·5	532·5	565·5	599·5	634·5	670·5	707·5	9
10	198·5	218·0	238·5	260·0	282·5	306·0	330·5	356·0	382·5	410·0	438·5	468·0	498·5	529·9	562·5	596·0	630·5	666·0	702·5	740·0	10
11	222·5	242·5	263·5	285·5	308·5	332·5	357·4	383·5	410·5	438·5	467·5	497·5	528·5	560·5	593·5	627·5	662·5	698·5	735·5	773·5	11
12	247·4	268·0	289·5	312·0	335·5	360·0	385·5	412·0	439·5	468·0	497·5	527·9	559·5	592·0	625·5	660·0	695·5	732·0	769·5	808·0	12
13	273·5	294·5	316·5	339·5	363·4	388·5	414·5	441·5	469·5	498·5	528·5	559·5	591·5	624·5	658·5	693·5	729·5	766·5	804·5	843·5	13
14	300·5	322·0	344·5	367·9	392·5	418·0	444·5	472·0	500·5	529·9	560·5	592·0	624·5	658·0	692·5	728·0	764·5	802·0	840·5	879·9	14
15	328·5	350·5	373·5	397·5	422·5	448·5	475·5	503·5	532·6	562·5	593·5	625·5	658·5	692·5	727·5	763·5	800·5	838·5	877·5	917·5	15
16	357·5	379·9	403·5	428·0	453·5	480·0	507·5	535·9	565·5	596·0	627·5	660·0	693·5	728·0	763·5	800·0	837·5	876·0	915·5	956·0	16
17	387·4	410·5	434·5	459·5	485·5	512·5	540·4	569·5	599·5	630·5	662·5	695·5	729·5	764·5	800·5	837·5	875·5	914·5	954·5	995·5	17
18	418·5	442·0	466·5	492·0	518·5	546·0	574·5	604·0	634·5	666·0	698·5	732·0	766·5	802·0	838·5	876·0	914·5	954·0	994·5	1036·	18
19	450·5	474·5	499·5	525·5	552·4	580·5	609·5	639·5	670·5	702·5	735·5	769·5	804·5	840·5	877·5	915·5	954·5	994·5	1035·	1077·	19
20	483·5	508·0	533·5	559·9	587·5	616·0	645·5	676·0	707·5	740·0	773·5	808·0	843·5	879·9	917·5	956·0	995·5	1036·	1077·	1120·	20

TABLE XLVIII.—Base 26.—Slopes 2 to 1.

Feet.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Feet.
0	13·66	28·65	45·01	62·67	81·65	102·0	123·6	146·6	171·0	196·7	223·7	252·0	281·6	312·7	345·0	378·6	413·6	449·9	487·7	526·7	0
1	27·97	43·69	60·67	79·00	98·63	119·6	141·9	165·7	190·7	217·0	244·6	273·9	304·0	335·7	368·6	403·0	438·6	475·7	514·0	553·7	1
2	43·69	59·99	77·65	96·63	117·0	138·6	161·7	186·0	211·6	238·6	267·0	296·7	327·7	360·0	393·6	428·6	465·0	502·7	541·7	582·0	2
3	60·67	77·65	95·98	115·6	136·6	159·0	182·7	207·6	234·0	261·6	290·7	321·0	352·6	385·6	419·9	455·7	492·7	531·0	570·6	611·6	3
4	79·00	96·63	115·6	135·9	157·7	180·7	205·0	230·6	257·6	286·0	315·6	346·6	379·0	412·6	447·7	484·0	521·7	560·6	601·0	642·6	4
5	98·63	117·0	136·6	157·7	180·0	203·7	228·6	255·0	282·7	311·7	342·0	373·6	406·6	441·0	476·7	513·7	552·0	591·6	632·6	675·0	5
6	119·6	138·6	159·0	180·7	203·7	228·0	253·6	280·7	309·0	338·7	369·6	401·9	435·7	470·7	507·0	544·6	583·6	624·0	665·7	708·7	6
7	141·9	161·7	182·7	205·0	228·6	253·6	280·0	307·7	336·6	366·9	398·6	431·7	466·0	501·7	538·6	577·0	616·6	657·7	700·0	743·7	7
8	165·7	186·0	207·6	230·6	255·0	280·7	307·7	336·0	365·6	396·6	429·0	462·7	497·7	534·0	571·6	610·6	651·0	692·7	735·7	780·0	8
9	190·7	211·6	234·0	257·6	282·7	309·0	336·6	365·6	395·9	427·7	460·7	495·0	530·6	567·6	606·0	645·7	686·7	729·0	772·6	817·6	9
10	217·0	238·6	261·6	286·0	311·7	338·7	366·9	396·6	427·7	460·0	493·7	528·7	565·0	602·6	641·7	682·0	723·6	766·7	811·0	856·7	10
11	244·6	267·0	290·7	315·6	342·0	369·6	398·6	429·0	460·7	493·7	528·0	563·6	600·6	639·0	678·7	719·6	762·0	805·6	850·7	897·0	11
12	273·9	296·7	321·0	346·6	373·6	401·9	431·7	462·7	495·0	528·7	563·6	600·0	637·7	676·7	717·0	758·6	801·6	846·0	891·7	938·6	12
13	304·0	327·7	352·6	379·0	406·6	435·7	466·0	497·7	530·6	565·0	600·6	637·7	676·0	715·7	756·6	799·0	842·7	887·7	934·0	981·6	13
14	335·7	360·0	385·6	412·6	441·0	470·7	501·7	534·0	567·6	602·6	639·0	676·7	715·7	756·0	797·6	840·7	885·0	930·7	977·6	1026·	14
15	368·6	393·6	419·9	447·7	476·7	507·0	538·6	571·6	606·0	641·7	678·7	717·0	756·6	797·6	840·0	883·6	928·7	975·0	1023·	1072·	15
16	403·0	428·6	455·7	484·0	513·7	544·6	577·0	610·6	645·7	682·0	719·6	758·6	799·0	840·7	883·6	928·0	973·6	1021·	1069·	1119·	16
17	438·6	465·0	492·7	521·7	552·0	583·6	616·6	651·0	686·7	723·6	762·0	801·6	842·7	885·0	928·7	973·6	1020·	1068·	1117·	1167·	17
18	475·7	502·7	531·0	560·6	591·6	624·0	657·7	692·7	729·0	766·7	805·6	846·0	887·7	930·7	975·0	1021·	1068·	1116·	1166·	1217·	18
19	514·0	541·7	570·6	601·0	632·6	665·7	700·0	735·7	772·6	811·0	850·7	891·7	934·0	977·6	1023·	1069·	1117·	1166·	1216·	1268·	19
20	553·7	582·0	611·6	642·6	675·0	708·7	743·7	780·0	817·6	856·7	897·0	938·6	981·6	1026·	1072·	1119·	1167·	1217·	1268·	1320·	20

TABLE XLIX.—Base 1.—Slopes ½ to 1.

Feet.	1		2		3		4		5		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·0185	·006	·0370	·025	·0556	·056	·0741	·099	·0926	·154	0
1	·0370	·019	·0556	·043	·0741	·080	·0926	·130	·1111	·192	1
2	·0556	·043	·0741	·074	·0926	·117	·1111	·173	·1296	·241	2
3	·0741	·080	·0926	·117	·1111	·167	·1296	·228	·1481	·302	3
4	·0926	·130	·1111	·173	·1296	·228	·1481	·296	·1667	·377	4
5	·1111	·192	·1296	·241	·1481	·302	·1667	·377	·1852	·463	5
6	·1296	·265	·1481	·321	·1667	·389	·1852	·469	·2037	·562	6
7	·1481	·352	·1667	·414	·1852	·488	·2037	·574	·2222	·673	7
8	·1667	·451	·1852	·519	·2037	·599	·2222	·691	·2407	·796	8
9	·1852	·562	·2037	·636	·2222	·722	·2407	·821	·2593	·932	9
10	·2037	·685	·2222	·765	·2407	·858	·2593	·963	·2778	1·080	10
11	·2222	·821	·2407	·907	·2593	1·006	·2778	1·117	·2963	1·241	11
12	·2407	·969	·2593	1·062	·2778	1·167	·2963	1·284	·3148	1·414	12
13	·2593	1·130	·2778	1·228	·2963	1·340	·3148	1·463	·3333	1·599	13
14	·2778	1·302	·2963	1·407	·3148	1·525	·3333	1·654	·3519	1·796	14
15	·2963	1·488	·3148	1·599	·3333	1·722	·3519	1·858	·3704	2·006	15
16	·3148	1·865	·3333	1·802	·3519	1·932	·3704	2·074	·3889	2·228	16
17	·3333	1·895	·3519	2·019	·3704	2·154	·3889	2·302	·4074	2·463	17
18	·3519	2·117	·3704	2·247	·3889	2·389	·4074	2·543	·4259	2·710	18
19	·3704	2·352	·3889	2·488	·4074	2·636	·4259	2·796	·4444	2·969	19
20	·3889	2·599	·4074	2·741	·4259	2·895	·4444	3·062	·4630	3·241	20
21	·4074	2·858	·4259	3·006	·4444	3·167	·4630	3·340	·4815	3·525	21
22	·4259	3·130	·4444	3·284	·4630	3·451	·4815	3·630	·5000	3·821	22
23	·4444	3·414	·4630	3·574	·4815	3·747	·5000	3·932	·5185	4·130	23
24	·4630	3·710	·4815	3·877	·5000	4·056	·5185	4·247	·5370	4·451	24
25	·4815	4·019	·5000	4·191	·5185	4·377	·5370	4·574	·5556	4·784	25
26	·5000	4·340	·5185	4·519	·5370	4·710	·5556	4·914	·5741	5·130	26
27	·5185	4·673	·5370	4·858	·5556	5·056	·5741	5·265	·5926	5·488	27
28	·5370	5·019	·5556	5·210	·5741	5·414	·5926	5·630	·6111	5·858	28
29	·5556	5·377	·5741	5·574	·5926	5·784	·6111	6·006	·6296	6·241	29
30	·5741	5·747	·5926	5·951	·6111	6·167	·6296	6·395	·6481	6·636	30
31	·5926	6·130	·6111	6·340	·6296	6·562	·6481	6·796	·6667	7·043	31
32	·6111	6·525	·6296	6·741	·6481	6·969	·6667	7·210	·6852	7·463	32
33	·6296	6·932	·6481	7·154	·6667	7·389	·6852	7·636	·7037	7·895	33
34	·6481	7·352	·6667	7·580	·6852	7·821	·7037	8·074	·7222	8·340	34
35	·6667	7·784	·6852	8·019	·7037	8·265	·7222	8·525	·7407	8·796	35
36	·6852	8·228	·7037	8·469	·7222	8·722	·7407	8·988	·7593	9·265	36
37	·7037	8·685	·7222	8·932	·7407	9·191	·7593	9·463	·7778	9·747	37
38	·7222	9·154	·7407	9·407	·7593	9·673	·7778	9·951	·7963	10·241	38
39	·7407	9·636	·7593	9·895	·7778	10·167	·7963	10·451	·8148	10·747	39
40	·7593	10·130	·7778	10·395	·7963	10·673	·8148	10·963	·8333	11·265	40

TABLE L.—Base 1.—Slopes ½ to 1.

Feet.	6		7		8		9		10		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·1111	·222	·1296	·302	·1481	·395	·1667	·500	·1852	·617	0
1	·1296	·265	·1481	·352	·1667	·451	·1852	·562	·2037	·685	1
2	·1481	·321	·1667	·414	·1852	·519	·2037	·636	·2222	·765	2
3	·1667	·389	·1852	·488	·2037	·599	·2222	·722	·2407	·858	3
4	·1852	·469	·2037	·574	·2222	·691	·2407	·821	·2593	·963	4
5	·2037	·562	·2222	·673	·2407	·796	·2593	·932	·2778	1·080	5
6	·2222	·667	·2407	·784	·2593	·914	·2778	1·056	·2963	1·210	6
7	·2407	·784	·2593	·907	·2778	1·043	·2963	1·191	3148	1·352	7
8	·2593	·914	·2778	1·043	·2963	1·185	·3148	1·340	·3333	1·506	8
9	·2778	1·056	·2963	1·191	·3148	1·340	·3333	1·500	·3519	1·673	9
10	·2963	1·210	·3148	1·352	·3333	1·506	·3519	1·673	·3704	1·852	10
11	·3148	1·377	·3333	1·525	·3519	1·685	·3704	1·858	·3889	2·043	11
12	·3333	1·556	·3519	1·710	·3704	1·877	·3889	2·056	·4074	2·247	12
13	·3519	1·747	·3704	1·907	·3889	2·080	·4074	2·265	·4259	2·463	13
14	·3704	1·951	·3889	2·117	·4074	2·296	·4259	2·488	·4444	2·691	14
15	·3889	2·167	·4074	2·340	·4259	2·525	·4444	2·722	·4630	2·932	15
16	·4074	2·395	·4259	2·574	·4444	2·765	·4630	2·969	·4815	3·185	16
17	·4259	2·636	·4444	2·821	·4630	3·019	·4815	3·228	·5000	3·451	17
18	·4444	2·889	·4630	3·080	·4815	3·284	·5000	3·500	·5185	3·728	18
19	·4630	3·154	·4815	3·352	·5000	3·562	·5185	3·784	·5370	4·019	19
20	·4815	3·432	·5000	3·636	·5185	3·852	·5370	4·080	·5556	4·321	20
21	·5000	3·722	·5185	3·932	·5370	4·154	·5556	4·389	·5741	4·636	21
22	·5185	4·025	·5370	4·241	·5556	4·469	·5741	4·710	·5926	4·963	22
23	·5370	4·340	·5556	4·562	·5741	4·796	·5926	5·043	·6111	5·302	23
24	·5556	4·667	·5741	4·895	·5926	5·136	·6111	5·389	·6296	5·654	24
25	·5741	5·006	·5926	5·241	·6111	5·488	·6296	5·747	6481	6·019	25
26	·5926	5·358	·6111	5·599	·6296	5·852	·6481	6·117	·6667	6·395	26
27	·6111	5·722	·6296	5·969	·6481	6·228	·6667	6·500	·6852	6·784	27
28	·6296	6·099	·6481	6·352	·6667	6·617	·6852	6·895	·7037	7·185	28
29	·6481	6·488	·6667	6·747	·6852	7·019	·7037	7·302	·7222	7·599	29
30	·6667	6·889	·6852	7·154	·7037	7·432	·7222	7 722	·7407	8·025	30
31	·6852	7·302	·7037	7·574	·7222	7·858	·7407	8·154	·7593	8·463	31
32	·7037	7·728	·7222	8·006	·7407	8·296	·7593	8·599	·7778	8·914	32
33	·7222	8·167	·7407	8·451	·7593	8·747	·7778	9·056	·7963	9·377	33
34	·7407	8·617	·7593	8·907	·7778	9·210	·7963	9·525	·8148	9·852	34
35	·7593	9·080	·7778	9·377	·7963	9·685	·8148	10·006	·8333	10·340	35
36	·7778	9·556	·7963	9·858	·8148	10·173	·8333	10·500	·8519	10·840	36
37	·7963	10·043	·8148	10·352	·8333	10·673	·8519	11·006	·8704	11·352	37
38	·8148	10·543	·8333	10·858	·8519	11·185	·8704	11·525	·8889	11·877	38
39	·8333	11·056	·8519	11·377	·8704	11·710	·8889	12 056	·9074	12·414	39
40	·8519	11·580	·8704	11·907	·8889	12·247	·9074	12·599	·9259	12·963	40

TABLE LI.—Base 1.—Slopes ½ to 1.

Feet.	11		12		13		14		15		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2037	·747	·2222	·889	·2407	1·043	·2593	1·210	·2778	1·389	0
1	·2222	·821	·2407	·969	·2593	1·130	·2778	1·302	·2963	1·488	1
2	·2407	·907	·2593	1·062	·2778	1·228	·2963	1·407	·3148	1·599	2
3	·2593	1·006	·2778	1·167	·2963	1·340	·3148	1·525	·3333	1·722	3
4	·2778	1·117	·2963	1·284	·3148	1·463	·3333	1·654	·3519	1·858	4
5	·2963	1·241	·3148	1·414	·3333	1·599	·3519	1·796	·3704	2·006	5
6	·3148	1·377	·3333	1·556	·3519	1·747	·3704	1·951	·3889	2·167	6
7	·3333	1·525	·3519	1·710	·3704	1·907	·3889	2·117	·4074	2·340	7
8	·3519	1·685	·3704	1·877	·3889	2·080	·4074	2·296	·4259	2·525	8
9	·3704	1·858	·3889	2·056	·4074	2·265	·4259	2·488	·4444	2·722	9
10	·3889	2·043	·4074	2·247	·4259	2·463	·4444	2·691	·4630	2·932	10
11	·4074	2·241	·4259	2·451	·4444	2·673	·4630	2·907	·4815	3·154	11
12	·4259	2·451	·4444	2·667	·4630	2·895	·4815	3·136	·5000	3·389	12
13	·4444	2·673	·4630	2·895	·4815	3·130	·5000	3·377	·5185	3·636	13
14	·4630	2·907	·4815	3·136	·5000	3·377	·5185	3·630	·5370	3·895	14
15	·4815	3·154	·5000	3·389	·5185	3·636	·5370	3·895	·5556	4·167	15
16	·5000	3·414	·5185	3·654	·5370	3·907	·5556	4·173	·5741	4·451	16
17	·5185	3·685	·5370	3·932	·5556	4·191	·5741	4·463	·5926	4·747	17
18	·5370	3 969	·5556	4·222	·5741	4·488	·5926	4·765	·6111	5·056	18
19	·5556	4·265	·5741	4·525	·5926	4·796	·6111	5·080	·6296	5·377	19
20	·5741	4·574	·5926	4·840	·6111	5·117	·6296	5·407	·6481	5·710	20
21	·5926	4·895	·6111	5·167	·6296	5·451	·6481	5·747	·6667	6·056	21
22	·6111	5·228	·6296	5·506	·6481	5·796	·6667	6·099	·6852	6·414	22
23	·6296	5·574	·6481	5·858	·6667	6·154	·6852	6·463	·7037	6·784	23
24	·6481	5·932	·6667	6·222	·6852	6·525	·7037	6·840	·7222	7·167	24
25	·6667	6·302	·6852	6·599	·7037	6·907	·7222	7·228	·7407	7·562	25
26	·6852	6·685	·7037	6·988	·7222	7·302	·7407	7·630	·7593	7·969	26
27	·7037	7·080	·7222	7·389	·7407	7·710	·7593	8·043	·7778	8·389	27
28	·7222	7·488	·7407	7·802	·7593	8·130	·7778	8·469	·7963	8·821	28
29	·7407	7·907	·7593	8·228	·7778	8·562	·7963	8·907	·8148	9·265	29
30	·7593	8·340	·7778	8·667	·7963	9·006	·8148	9·358	·8333	9·722	30
31	·7778	8·784	·7963	9·117	·8148	9·463	·8333	9·821	·8519	10·191	31
32	·7963	9·241	·8148	9·580	·8333	9·932	·8519	10·296	·8704	10·673	32
33	·8148	9·710	·8333	10·056	·8519	10·414	·8704	10·784	·8889	11·167	33
34	·8333	10·191	·8519	10·543	·8704	10·907	·8889	11·284	·9074	11·673	34
35	·8519	10·685	·8704	11·043	·8889	11·414	·9074	11·796	·9259	12·191	35
36	·8704	11·191	·8889	11·556	·9074	11·932	·9259	12·321	·9444	12·722	36
37	·8889	11·710	·9074	12·080	·9259	12·463	·9444	12·858	·9630	13·265	37
38	·9074	12·241	·9259	12·617	·9444	13·006	·9630	13·407	·9815	13·821	38
39	·9259	12·784	·9444	13·167	·9630	13·562	·9815	13·969	1·0000	14·389	39
40	·9444	13·340	·9630	13·728	·9815	14·130	1·0000	14·543	1·0185	14·969	40

TABLE LII.—Base 1.—Slopes ½ to 1.

Feet.	16		17		18		19		20		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2963	1·580	·3148	1·784	·3333	2·000	·3519	2·228	·3704	2·469	0
1	·3148	1·685	·3333	1·895	·3519	2·117	·3704	2·352	·3889	2·599	1
2	·3333	1·802	·3519	2·019	·3704	2·247	·3889	2·488	·4074	2·741	2
3	·3519	1·932	·3704	2·154	·3889	2·389	·4074	2·636	·4259	2·895	3
4	·3704	2·074	·3889	2·302	·4074	2·543	·4259	2·796	·4444	3·062	4
5	·3889	2·228	·4074	2·463	·4259	2·710	·4444	2·969	·4630	3 241	5
6	·4074	2·395	·4259	2·636	·4444	2 889	·4630	3·154	·4815	3·432	6
7	·4259	2·574	·4444	2·821	·4630	3·080	·4815	3·352	·5000	3·636	7
8	·4444	2·765	·4630	3·019	·4815	3·284	·5000	3·562	·5185	3·852	8
9	·4630	2·969	·4815	3·228	·5000	3·500	·5185	3·784	·5370	4·080	9
10	·4815	3·185	·5000	3·451	·5185	3·728	·5370	4·019	·5556	4·321	10
11	·5000	3·414	·5185	3·685	·5370	39·69	·5556	4·265	·5741	4·574	11
12	·5185	3·654	·5370	3·932	·5556	4·222	·5741	4·525	·5926	4·840	12
13	·5370	3·907	·5556	4·191	·5741	4·488	·5926	4·796	·6111	5·117	13
14	·5556	4·173	·5741	4·463	·5926	4·765	·6111	5·080	·6296	5·407	14
15	·5741	4·451	·5926	4·747	·6111	5·056	·6296	5·377	·6481	5·710	15
16	·5926	4·741	·6111	5·043	·6296	5·358	·6481	5·685	·6667	6·025	16
17	·6111	5·043	·6296	5·352	·6481	5·673	·6667	6·006	·6852	6·352	17
18	·6296	5·358	·6481	5·673	·6667	6·000	·6852	6·340	·7037	6·691	18
19	·6481	5·685	·6667	6·006	·6852	6·340	·7037	6·685	·7222	7·043	19
20	·6667	6·025	·6852	6·352	·7037	6·691	·7222	7·043	·7407	7·407	20
21	·6852	6·377	·7037	6·710	·7222	7·056	·7407	7·414	·7593	7·784	21
22	·7037	6·741	·7222	7·080	·7407	7·432	·7593	7·796	·7778	8·173	22
23	·7222	7·117	·7407	7·463	·7593	7·821	·7778	8·191	·7963	8·574	23
24	·7407	7·506	·7593	7·858	·7778	8·222	·7963	8·599	·8148	8·988	24
25	·7593	7·907	·7778	8·265	·7963	8·636	·8148	9·019	·8333	9·414	25
26	·7778	8·321	·7963	8·685	·8148	9·062	·8333	9·451	·8519	9·852	26
27	·7963	8·747	·8148	9·117	·8333	9·500	·8519	9·895	·8704	10·302	27
28	·8148	9·185	·8333	9·562	·8519	9·951	·8704	10·352	·8889	10·765	28
29	·8333	9·636	·8519	10·019	8704	10·414	·8889	10·821	·9074	11·241	29
30	·8519	10·099	·8704	10·488	·8889	10·889	·9074	11·302	·9259	11·728	30
31	·8704	10·574	·8889	10·969	·9074	11·377	·9259	11·796	·9444	12·228	31
32	·8889	11·062	·9074	11·463	·9259	11·877	·9444	12·302	·9630	12·741	32
33	·9074	11·562	·9259	11·969	·9444	12·389	·9630	12·821	·9815	13·265	33
34	·9259	12·074	·9444	12·488	·9630	12·914	·9815	13·352	1·0000	13·803	34
35	·9444	12·599	·9630	13·019	·9815	13·451	1·0000	13·895	1·0185	14·352	35
36	·9630	13·136	·9815	13·562	1·0000	14·000	1·0185	14·451	1·0370	14·914	36
37	·9815	13·685	1·0000	14·117	1·0185	14·562	1·0370	15·019	1·0556	15·488	37
38	1·0000	14·247	1·0185	14·685	1·0370	15·136	1·0556	15·599	1·0741	16·074	38
39	1·0185	14·821	1·0370	15·265	1·0556	15·722	1·0741	16·191	1·0926	16·673	39
40	1·0370	15·407	1·0556	15·858	1·0741	16·321	1·0926	16·796	1·1111	17·284	40

TABLE LIII.—Base 1.—Slopes ½ to 1.

Feet.	21		22		23		24		25		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·3889	2·722	·4074	2·988	·4259	3·265	·4444	3·556	·4630	3·858	0
1	·4074	2·858	·4259	3·130	·4444	3·414	·4630	3·710	·4815	4·019	1
2	·4259	3·006	·4444	3·284	·4630	3·574	·4815	3·877	·5000	4·191	2
3	·4444	3·167	·4630	3·451	·4815	3·747	·5000	4·056	·5185	4·377	3
4	·4630	3·340	·4815	3·630	·5000	3·932	·5185	4·247	·5370	4·574	4
5	·4815	3·525	·5000	3·821	·5185	4·130	·5370	4·451	·5556	4·784	5
6	·5000	3·722	·5185	4·025	·5370	4·340	·5556	4·667	·5741	5·006	6
7	·5185	3·932	·5370	4·241	·5556	4·562	·5741	4·895	·5926	5·241	7
8	·5370	4·154	·5556	4·469	·5741	4·796	·5926	5·136	·6111	5·488	8
9	·5556	4·389	·5741	4·710	·5926	5·043	·6111	5·389	·6296	5·747	9
10	·5741	4·636	·5926	4·963	·6111	5·302	·6296	5·654	·6481	6·019	10
11	·5926	4·895	·6111	5·228	·6296	5·574	·6481	5·932	·6667	6·302	11
12	·6111	5·167	·6296	5·506	·6481	5·858	·6667	6·222	·6852	6·599	12
13	·6296	5·451	·6481	5·796	·6667	6·154	·6852	6·525	·7037	6·907	13
14	·6481	5·747	·6667	6·099	·6852	6·463	·7037	6·840	·7222	7·228	14
15	·6667	6·056	·6852	6·414	·7037	6·784	·7222	7·167	·7407	7·562	15
16	·6852	6·377	·7037	6 741	·7222	7·117	·7407	7·506	·7593	7·907	16
17	·7037	6·710	·7222	7·080	·7407	7·463	·7593	7·858	·7778	8·265	17
18	·7222	7·056	·7407	7·432	·7593	7·821	·7778	8·222	·7963	8·636	18
19	·7407	7·414	·7593	7·796	·7778	8·191	·7963	8·599	·8148	9·019	19
20	·7593	7·784	·7778	8·173	·7963	8 574	·8148	8·988	·8333	9·414	20
21	·7778	8·167	·7963	8·562	·8148	8·969	·8333	9·389	·8519	9·821	21
22	·7963	8·562	·8148	8·963	·8333	9·377	·8519	9·802	·8704	10·241	22
23	·8148	8·969	·8333	9·377	·8519	9·796	·8704	10·228	·8889	10·673	23
24	·8333	9·389	·8519	9·802	·8704	10·228	·8889	10·667	·9074	11·117	24
25	·8519	9 821	·8704	10·241	·8889	10·673	·9074	11·117	·9259	11·574	25
26	·8704	10·265	·8889	10·691	·9074	11·130	·9259	11·580	·9444	12·043	26
27	·8889	10·722	·9074	11·154	·9259	11·599	·9444	12·056	·9630	12·525	27
28	·9074	11·191	·9259	11·630	·9444	12·080	·9630	12·543	·9815	13·019	28
29	·9259	11·673	·9444	12·117	·9630	12·574	·9815	13·043	1·0000	13·525	29
30	·9444	12·167	·9630	12·617	·9815	13·080	1·0000	13·556	1·0185	14·043	30
31	·9630	12·673	·9815	13·130	1·0000	13·599	1·0185	14·080	1·0370	14·574	31
32	·9815	13·191	1·0000	13·654	1·0185	14·130	1·0370	14·617	1·0556	15·117	32
33	1·0000	13·722	1·0185	14·191	1·0370	14·673	1·0556	15·167	1·0741	15·673	33
34	1·0185	14·265	1·0370	14·741	1·0556	15·228	1·0741	15·728	1·0926	16·241	34
35	1·0370	14·821	1·0556	15·302	1·0741	15·796	1·0926	16·302	1·1111	16·821	35
36	1·0556	15·389	1·0741	15·877	1·0926	16·377	1·1111	16·889	1·1296	17·414	36
37	1·0741	15·969	1·0926	16·463	1·1111	16·969	1·1296	17·488	1·1481	18·019	37
38	1·0926	16·562	1·1111	17·062	1·1296	17·574	1·1481	18·099	1·1667	18·636	38
39	1·1111	17·167	1·1296	17·673	1·1481	18·191	1·1667	18·722	1·1852	19·265	39
40	1·1296	17·784	1·1481	18·296	1·1667	18·821	1·1852	19·358	1·2047	19·907	40

TABLE LIV.—Base 1.—Slopes ½ to 1.

Feet.	26		27		28		29		30		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·4815	4·173	·5000	4·500	·5185	4·840	·5370	5·191	·5556	5·556	0
1	·5000	4·340	·5185	4·673	·5370	5·019	·5556	5·377	·5741	5·747	1
2	·5185	4·519	·5370	4·858	·5556	5·210	·5741	5·574	·5926	5·951	2
3	·5370	4·710	·5556	5·056	·5741	5·414	·5026	5·784	·6111	6·167	3
4	·5556	4·914	·5741	5·265	·5926	5·630	·6111	6·006	·6296	6·395	4
5	·5741	5·130	·5926	5·488	·6111	5·858	·6296	6·241	·6481	6·636	5
6	·5926	5·358	·6111	5·722	·6296	6·099	·6481	6·488	·6667	6·889	6
7	·6111	5·599	·6296	5·969	·6481	6·352	·6667	6·747	·6852	7·154	7
8	·6296	5·852	·6481	6·228	·6667	6·617	·6852	7·019	·7037	7·432	8
9	·6481	6·117	·6667	6·500	·6852	6·895	·7037	7·302	·7222	7·722	9
10	·6667	6·395	·6852	6·784	·7037	7·185	·7222	7·599	·7407	8·025	10
11	·6852	6·685	·7037	7·080	·7222	7·488	·7407	7·907	·7593	8·340	11
12	·7037	6·988	·7222	7·389	·7407	7·802	·7593	8·228	·7778	8·667	12
13	·7222	7·302	·7407	7·710	·7593	8·130	·7778	8·562	·7963	9·006	13
14	·7407	7·630	·7593	8·043	·7778	8·469	·7963	8·907	·8148	9·358	14
15	·7593	7·969	·7778	8·389	·7963	8·821	·8148	9·265	·8333	9·722	15
16	·7778	8·321	·7963	8·747	·8148	9·185	·8333	9·636	·8519	10·099	16
17	·7963	8·685	·8148	9·117	·8333	9·562	·8519	10·019	·8704	10·488	17
18	·8148	9·062	·8333	9·500	·8519	9·951	·8704	10·414	·8889	10·889	18
19	·8333	9·451	·8519	9·895	·8704	10·352	·8889	10·821	·9074	11·302	19
20	·8519	9·852	·8704	1·0302	·8889	10·765	·9074	11·241	·9259	11·728	20
21	·8704	10·265	·8889	10·722	·9074	11·191	·9259	11·673	·9444	12·167	21
22	·8889	10·691	·9074	11·154	·9259	11·630	·9444	12·117	·9630	12·617	22
23	·9074	11·130	·9259	11·599	·9444	12·080	·9630	12·574	·9815	13·080	23
24	·9259	11·580	·9444	12·056	·9630	12·543	·9815	13·043	1·0000	13·556	24
25	·9444	12·043	·9630	12·525	·9815	13·019	1·0000	13·525	1·0185	14·043	25
26	·9630	12·519	·9815	13·006	1·0000	13·506	1·0185	14·019	1·0370	14·543	26
27	·9815	13·006	1·0000	13·500	1·0185	14·006	1·0370	14·525	1·0556	15·056	27
28	1·0000	13·506	1·0185	14·006	1·0370	14·519	1·0556	15·043	1·0741	15·580	28
29	1·0185	14·019	1·0370	14·525	1·0556	15·043	1·0741	15·574	1·0926	16·117	29
30	1·0370	14·543	1·0556	15·056	1·0741	15·580	1·0926	16·117	1·1111	16·667	30
31	1·0556	15·080	1·0741	15·599	1·0926	16·130	1·1111	16·673	1·1296	17·228	31
32	1·0741	15·630	1·0926	16·154	1·1111	16·691	1·1296	17·241	1·1481	17·802	32
33	1·0926	16·191	1·1111	16·722	1·1296	17·265	1·1481	17·821	1·1667	18·389	33
34	1·1111	16·765	1·1296	17·302	1·1481	17·852	1·1667	18·414	1·1852	18·988	34
35	1·1296	17·352	1·1481	17·895	1·1667	18·451	1·1852	19·019	1·2047	19·599	35
36	1·1481	17·951	1·1667	18·500	1·1852	19·062	1·2047	19·636	1·2222	20·222	36
37	1·1667	18·562	1·1852	19·117	1·2047	19·685	1·2222	20·265	1·2407	20·858	37
38	1·1852	19·185	1·2047	19·747	1·2222	20·321	1·2407	20·907	1·2593	21·506	38
39	1·2047	19·821	1·2222	20·389	1·2407	20·969	1·2593	21·562	1·2778	22·167	39
40	1·2222	20·469	1·2407	21·043	1·2593	21·630	1·2778	22·228	1·2963	22·840	40

TABLE LV.—Base 1.—Slopes ½ to 1.

Feet.	31		32		33		34		35		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·5741	5·932	·5926	6·321	·6111	6·722	·6296	7·136	·6481	7·562	0
1	·5926	6·130	·6111	6·525	·6296	6·932	·6481	7·352	·6667	7·784	1
2	·6111	6·340	·6296	6·741	·6481	7·154	·6667	7·580	·6852	8·019	2
3	·6296	6·562	·6481	6·969	·6667	7·389	·6852	7·821	·7037	8·265	3
4	·6481	6·796	·6667	7·210	·6852	7·636	·7037	8·074	·7222	8·525	4
5	·6667	7·043	·6852	7·463	·7037	7·895	·7222	8·340	·7407	8·796	5
6	·6852	7·302	·7037	7·728	·7222	8·167	·7407	8·617	·7593	9·080	6
7	·7037	7·574	·7222	8·006	·7407	8·451	·7593	8·907	·7778	9·377	7
8	·7222	7·858	·7407	8·296	·7593	8·747	·7778	9·210	·7963	9·685	8
9	·7407	8·154	·7593	8·599	·7778	9·056	·7963	9·525	·8148	10·006	9
10	·7593	8·463	·7778	8·914	·7963	9·377	·8148	9·852	·8333	10·340	10
11	·7778	8·784	·7963	9·241	·8148	9·710	·8333	10·191	·8519	10·685	11
12	·7963	9·117	·8148	9·580	·8333	10·056	·8519	10·543	·8704	11·043	12
13	·8148	9·463	·8333	9·932	·8519	10·414	·8704	10·907	·8889	11·414	13
14	·8333	9·821	·8519	10·296	·8704	10·784	·8889	11·284	·9074	11·796	14
15	·8519	10·191	·8704	10·673	·8889	11·167	·9074	11·673	·9259	12·191	15
16	·8704	10·574	·8889	11·062	·9074	11·562	·9259	12·074	·9444	12·599	16
17	·8889	10·969	·9074	11·463	·9259	11·969	·9444	12·488	·9630	13·019	17
18	·9074	11·377	·9259	11·877	·9444	12·389	·9630	12·914	·9815	13·451	18
19	·9259	11·796	·9444	12·302	·9630	12·821	·9815	13·352	1·0000	13·895	19
20	·9444	12·228	·9630	12·741	·9815	13·265	1·0000	13·803	1·0185	14·352	20
21	·9630	12·673	·9815	13·191	1·0000	13·722	1·0185	14·265	1·0370	14·821	21
22	·9815	13·130	1·0000	13·654	1·0185	14·191	1·0370	14·741	1·0556	15·302	22
23	1·0000	13·599	1·0185	14·130	1·0370	14·673	1·0556	15·228	1·0741	15·796	23
24	1·0185	14·080	1·0370	14·617	1·0556	15·167	1·0741	15·728	1·0926	16·302	24
25	1·0370	14·574	1·0556	15·117	1·0741	15·673	1·0926	16·241	1·1111	16·821	25
26	1·0556	15·080	1·0741	15·630	1·0926	16·191	1·1111	16·765	1·1296	17·352	26
27	1·0741	15·599	1·0926	16·154	1·1111	16·722	1·1296	17·302	1·1481	17·895	27
28	1·0926	16·130	1·1111	16·691	1·1296	17·265	1·1481	17·852	1·1667	18·451	28
29	1·1111	16·673	1·1296	17·241	1·1481	17·821	1·1667	18·414	1·1852	19·019	29
30	1·1296	17·228	1·1481	17·802	1·1667	18·389	1·1852	18·988	1·2047	19·599	30
31	1·1481	17·796	1·1667	18·377	1·1852	18·969	1·2047	19·574	1·2222	20·191	31
32	1·1667	18·377	1·1852	18·963	1·2047	19·562	1·2222	20·173	1·2407	20·796	32
33	1·1852	18·969	1·2047	19·562	1·2222	20·167	1·2407	20·784	1·2593	21·414	33
34	1·2047	19·574	1·2222	20·173	1·2407	20·784	1·2593	21·407	1·2778	22·043	34
35	1·2222	20·191	1·2407	20·796	1·2593	21·414	1·2778	22·043	1·2963	22·685	35
36	1·2407	20·821	1·2593	21·432	1·2778	22·056	1·2963	22·691	1·3148	23·340	36
37	1·2593	21·463	1·2778	22·080	1·2963	22·710	1·3148	23·352	1·3333	24·006	37
38	1·2778	22·117	1·2963	22·741	1·3148	23·377	1·3333	24·025	1·3519	24·685	38
39	1·2963	22·784	1·3148	23·414	1·3333	24·056	1·3519	24·710	1·3704	25·377	39
40	1·3148	23·463	1·3333	24·099	1·3519	24·747	1·3704	25·407	1·3889	26·080	40

TABLE LVI.—Base 1.—Slopes ½ to 1.

Feet.	36		37		38		39		40		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·6667	8·000	·6852	8·451	·7037	8·914	·7222	9·389	·7407	9·877	0
1	·6852	8·228	·7037	8·685	·7222	9·154	·7407	9·636	·7593	10·130	1
2	·7037	8·469	·7222	8·932	·7407	9·407	·7593	9·895	·7778	10·395	2
3	·7222	8·722	·7407	9·191	·7593	9·673	·7778	10·167	·7963	10·673	3
4	·7407	8·988	·7593	9·463	·7778	9·951	·7963	10·451	·8148	10·963	4
5	·7593	9·265	·7778	9·747	·7963	10·241	·8148	10·747	·8333	11·265	5
6	·7778	9·556	·7963	10·043	·8148	10·543	·8333	11·056	·8519	11·580	6
7	·7963	9·858	·8148	10·352	·8333	10·858	·8519	11·377	·8704	11·907	7
8	·8148	10·173	·8333	10·673	·8519	11·185	·8704	11·710	·8889	12·247	8
9	·8333	10·500	·8519	11·006	·8704	11·525	·8889	12·056	·9074	12·599	9
10	·8519	10·840	·8704	11·352	·8889	11·877	·9074	12·414	·9259	12·963	10
11	·8704	11·191	·8889	11·710	·9074	12·241	·9259	12·784	·9444	13·340	11
12	·8889	11·556	·9074	12·080	·9259	12·617	·9444	13·167	·9630	13·728	12
13	·9074	11·932	·9259	12·463	·9444	13·006	·9630	13·562	·9815	14·130	13
14	·9259	12·321	·9444	12·858	·9630	13·407	·9815	13·969	1·0000	14·543	14
15	·9444	12·722	·9630	13·265	·9815	13·821	1·0000	14·389	1·0185	14·969	15
16	·9630	13·136	·9815	13·685	1·0000	14·247	1·0185	14·821	1·0370	15·407	16
17	·9815	13·562	1·0000	14·117	1·0185	14·685	1·0370	15·265	1·0556	15·858	17
18	1·0000	14·000	1·0185	14·562	1·0370	15·136	1·0556	15·722	1·0741	16·321	18
19	1·0185	14·451	1·0370	15·019	1·0556	15·599	1·0741	16·191	1·0926	16·796	19
20	1·0370	14·914	1·0556	15·488	1·0741	16·074	1·0926	16·673	1·1111	17·284	20
21	1·0556	15·389	1·0741	15·969	1·0926	16·562	1·1111	17·167	1·1296	17·784	21
22	1·0741	15·877	1·0926	16·463	1·1111	17·062	1·1296	17·673	1·1481	18·296	22
23	1·0926	16·377	1·1111	16·969	1·1296	17·574	1·1481	18·191	1·1667	18·821	23
24	1·1111	16·889	1·1296	17·488	1·1481	18·099	1·1667	18·722	1·1852	19·358	24
25	1·1296	17·414	1·1481	18·019	1·1667	18·636	1·1852	19·265	1·2047	19·907	25
26	1·1481	17·951	1·1667	18·562	1·1852	19·185	1·2047	19·821	1·2222	20·469	26
27	1·1667	18·500	1·1852	19·117	1·2047	19·747	1·2222	20·389	1·2407	21·043	27
28	1·1852	19·062	1·2047	19·685	1·2222	20·321	1·2407	20·969	1·2593	21·630	28
29	1·2047	19·636	1·2222	20·265	1·2407	20·907	1·2593	21·562	1·2778	22·228	29
30	1·2222	20·222	1·2407	20·858	1·2593	21·506	1·2778	22·167	1·2963	22·840	30
31	1·2407	20·821	1·2593	21·463	1·2778	22·117	1·2963	22·784	1·3148	23·463	31
32	1·2593	21·432	1·2778	22·080	1·2963	22·741	1·3148	23·414	1·3333	24·099	32
33	1·2778	22·056	1·2963	22·710	1·3148	23·377	1·3333	24·056	1·3519	24·747	33
34	1·2963	22·691	1·3148	23·352	1·3333	24·025	1·3519	24·710	1·3704	25·407	34
35	1·3148	23·340	1·3333	24·006	1·3519	24·685	1·3704	25·377	1·3889	26·080	35
36	1·3333	24·000	1·3519	24·673	1·3704	25·358	1·3889	26·056	1·4074	26·765	36
37	1·3519	24·673	1·3704	25·352	1·3889	26·043	1·4074	26·747	1·4259	27·463	37
38	1·3704	25·358	1·3889	26·043	1·4074	26·741	1·4259	27·451	1·4444	28·173	38
39	1·3889	26·056	1·4074	26·747	1·4259	27·451	1·4444	28·167	1·4630	28·895	39
40	1·4074	26 765	1·4259	27·463	1·4444	28·173	1·4630	28·895	1·4815	29·630	40

TABLE LVII.—Base 1.—Slopes 1 to 1.

Feet.	1		2		3		4		5		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·0185	·012	·0370	·049	·0556	·111	·0741	·198	·0926	·308	0
1	·0370	·037	·0556	·086	·0741	·160	·0926	·259	·1111	·383	1
2	·0556	·086	·0741	·148	·0926	·235	·1111	·346	·1296	·481	2
3	·0741	·160	·0926	·235	·1111	·333	·1296	·457	·1481	·605	3
4	·0926	·259	·1111	·346	·1296	·457	·1481	·593	·1667	·753	4
5	·1111	·383	·1296	·481	·1481	·605	·1667	·753	·1852	·926	5
6	·1296	·531	·1481	·642	·1667	·778	·1852	·938	·2037	1·123	6
7	·1481	·704	·1667	·827	·1852	·975	·2037	1·148	·2222	1·346	7
8	·1667	·901	·1852	1·037	·2037	1·296	·2222	1·383	·2407	1·593	8
9	·1852	1·123	·2037	1·272	·2222	1·444	·2407	1·642	·2593	1·864	9
10	·2037	1·370	·2222	1·531	·2407	1·716	·2593	1·926	·2778	2·160	10
11	·2222	1·642	·2407	1·815	·2593	2·012	·2778	2·235	·2963	2·481	11
12	·2407	1·938	·2593	2·123	·2778	2·333	·2963	2·568	·3148	2·827	12
13	·2593	2·259	·2778	2·457	·2963	2·679	·3148	2·926	·3333	3·198	13
14	·2778	2·605	·2963	2·815	·3148	3·049	·3333	3·309	·3519	3·593	14
15	·2963	2·975	·3148	3·198	·3333	3 444	·3519	3·716	·3704	4·012	15
16	·3148	3·370	·3333	3·605	·3519	3·864	·3704	4·148	·3889	4·457	16
17	·3333	3·790	·3519	4·037	·3704	4·309	·3889	4·605	·4074	4·926	17
18	·3519	4·235	·3704	4·494	·3889	4·778	·4074	5·086	·4259	5·420	18
19	·3704	4·704	·3889	4·975	·4074	5·272	·4259	5·593	·4444	5·938	19
20	·3889	5·198	·4074	5·481	·4259	5·790	·4444	6·061	·4630	6·481	20
21	·4074	5·716	·4259	6·012	·4444	6·333	·4630	6·679	·4815	7·049	21
22	·4259	6·259	·4444	6·568	·4630	6·901	·4815	7·259	·5000	7·642	22
23	·4444	6·827	·4630	7·148	·4815	7·494	·5000	7·864	·5185	8·259	23
24	·4630	7·420	·4815	7·753	·5000	8·111	·5185	8·494	·5370	8·901	24
25	·4815	8·037	·5000	8·383	·5185	8·573	·5370	9·148	·5556	9·568	25
26	·5000	8·679	·5185	9·037	·5370	9·420	·5556	9·827	·5741	10·259	26
27	·5185	9·346	·5370	9·716	·5556	10·111	·5741	10·531	·5926	10·975	27
28	·5370	10·037	·5556	10·420	·5741	10·827	·5926	11·259	·6111	11·716	28
29	·5556	10·753	·5741	11·148	·5926	11·568	·6111	12·012	·6296	12·481	29
30	·5741	11·494	·5926	11·901	·6111	12·333	·6296	12·790	·6481	13·272	30
31	·5926	12·259	·6111	12·679	·6296	13·123	·6481	13·593	·6667	14·086	31
32	·6111	13·049	·6296	13·481	·6481	13·938	·6667	14·420	·6852	14·926	32
33	·6296	13·864	·6481	14·309	·6667	14·778	·6852	15·272	·7037	15·790	33
34	·6481	14·704	·6667	15·160	·6852	15·642	·7037	16·148	·7222	17·679	34
35	·6667	15·568	·6852	16·037	·7037	16·531	·7222	17·049	·7407	17·593	35
36	·6852	16·457	·7037	16·938	·7222	17·444	·7407	17·975	·7593	18·531	36
37	·7037	17·370	·7222	17·864	·7407	18·383	·7593	18·926	·7778	19·494	37
38	·7222	18·309	·7407	18·815	·7593	19·346	·7778	19·901	·7963	20·481	38
39	·7407	19·272	·7593	19·790	·7778	20·333	·7963	20·901	·8148	21·494	39
40	·7593	20·259	·7778	20·790	·7963	21·346	·8148	21·926	·8333	22·531	40

TABLE LVIII.—Base 1.—Slopes 1 to 1.

Feet.	6		7		8		9		10		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·1111	·444	·1296	·605	·1481	·790	·1667	1·000	·1852	1·235	0
1	·1296	·531	·1481	·704	·1667	·901	·1852	1·123	·2037	1·370	1
2	·1481	·642	·1667	·827	·1852	1·037	·2037	1·272	·2222	1·531	2
3	·1667	·778	·1852	·975	·2037	1·198	·2222	1·444	·2407	1·716	3
4	·1852	·938	·2037	1·148	·2222	1·383	·2407	1·642	·2593	1·926	4
5	·2037	1·123	·2222	1·346	·2407	1·593	·2593	1·864	·2778	2·160	5
6	·2222	1·333	·2407	1·568	·2593	1·827	·2778	2·111	·2963	2·420	6
7	·2407	1·568	·2593	1·815	·2778	2·086	·2963	2·383	·3148	2·704	7
8	·2593	1·827	·2778	2·086	·2963	2·370	·3148	2·679	·3333	3·012	8
9	·2778	2·111	·2963	2·383	·3148	2·679	·3333	3·000	·3519	3·346	9
10	·2963	2·420	·3148	2·704	·3333	3·012	·3519	3·346	·3704	3·704	10
11	·3148	2·753	·3333	3·049	·3519	3·370	·3704	3·716	·3889	4·086	11
12	·3333	3·111	·3519	3·420	·3704	3·553	·3889	4·111	·4074	4·494	12
13	·3519	3·494	·3704	3·815	·3889	4·160	·4074	4·531	·4259	4·926	13
14	·3704	3·901	·3889	4·235	·4074	4·593	·4259	4·975	·4444	5·383	14
15	·3889	4·333	·4074	4·679	·4259	5·049	·4444	5·444	·4630	5·864	15
16	·4074	4·790	·4259	5·148	·4444	5·531	·4630	5·938	·4815	6·370	16
17	·4259	5·272	·4444	5·642	·4630	6·037	·4815	6·457	·5000	6·910	17
18	·4444	5·778	·4630	6·160	·4815	6·568	·5000	7·000	·5185	7·457	18
19	·4630	6·309	·4815	6·704	·5000	7·123	·5185	7·568	·5370	8·037	19
20	·4815	6·864	·5000	7·272	·5185	7·704	·5370	8·160	·5556	8·642	20
21	·5000	7·444	·5185	7·864 c	·5370	8·309	·5556	8·778	·5741	9·272	21
22	·5185	8·049	·5370	8·481	·5556	8·938	·5741	9·420	·5926	9·926	22
23	·5370	8·679	·5556	9·123	·5741	9·593	·5926	10·086	·6111	10·605	23
24	·5556	9·333	·5741	9·790	·5926	10·272	·6111	10·778	·6296	11·309	24
25	·5741	10·012	·5926	10·481	·6111	10·975	·6296	11·494	·6481	12·037	25
26	·5926	10·716	·6111	11·198	·6296	11·704	·6481	12·235	·6667	12·790	26
27	·6111	11·444	·6296	11·938	·6481	12·457	·6667	13·000	·6852	13·568	27
28	·6296	12·198	·6481	12·704	·6667	13·235	·6852	13·790	·7037	14·370	28
29	·6481	12·975	·6667	13·494	·6852	14·037	·7037	14·605	·7222	15·198	29
30	·6667	13·778	·6852	14·309	·7037	14·864	·7222	15·444	·7407	16·049	30
31	·6852	14·605	·7037	15·148	·7222	15·716	·7407	16·309	·7593	16·926	31
32	·7037	15·457	·7222	16·012	·7407	16·593	·7593	17·198	·7778	17·827	32
33	·7222	16·333	·7407	16·901	·7593	17·494	·7778	18·111	·7963	18·753	33
34	·7407	17·235	·7593	17·815	·7778	18·420	·7963	19·049	·8148	19·704	34
35	·7593	18·160	·7778	18·753	·7963	19·370	·8148	20·012	·8333	20·679	35
36	·7778	19·111	·7963	19·716	·8148	20·346	·8333	21·000	·8519	21·679	36
37	·7963	20·086	·8148	20·704	·8333	21·346	·8519	22·012	·8704	22·704	37
38	·8148	21·086	·8333	21·716	·8519	22·370	·8704	23·049	·8889	23·753	38
39	·8333	22·111	·8519	22·753	·8704	23·420	·8889	24·111	·9074	24·827	39
40	·8519	23·160	·8704	23·815	·8889	24·494	·9074	25·198	·9259	25·926	40

TABLE LIX.—Base 1.—Slopes 1 to 1.

Feet.	11		12		13		14		15		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2037	1·494	·2222	1·778	·2407	2·086	·2593	2·420	·2778	2·778	0
1	·2222	1·642	·2407	1·938	·2593	2·259	·2778	2·605	·2963	2·975	1
2	·2407	1·815	·2593	2·123	·2778	2·457	·2963	2·815	·3148	3·198	2
3	·2593	2·012	·2778	2·333	·2963	2·679	·3148	3·049	·3333	3·444	3
4	·2778	2·235	·2963	2·568	·3148	2·926	·3333	3·309	·3519	3·716	4
5	·2963	2·481	·3148	2·827	·3333	3·198	·3519	3·593	·3704	4·012	5
6	·3148	2·753	·3333	3·111	·3519	3·494	·3704	3·901	·3889	4·333	6
7	·3333	3·049	·3519	3·420	·3704	3·815	·3889	4·235	·4074	4·679	7
8	·3519	3·370	·3704	3·753	·3889	4·161	·4074	4·593	·4259	5·049	8
9	·3704	3·716	·3889	4·111	·4074	4·531	·4259	4·975	·4444	5·444	9
10	·3889	4·086	·4074	4·494	·4259	4·926	·4444	5·383	·4630	5·864	10
11	·4074	4·481	·4259	4·901	·4444	5·346	·4630	5·815	·4815	6·309	11
12	·4259	4·901	·4444	5·333	·4630	5·790	·4815	6·272	·5000	6·778	12
13	·4444	5·346	·4630	5·790	·4815	6·259	·5000	6·753	·5185	7·272	13
14	·4630	5·815	·4815	6·272	·5000	6·753	·5185	7·259	·5370	7·790	14
15	·4815	6·309	·5000	6·778	·5185	7·272	·5370	7·790	·5556	8·333	15
16	·5000	6·827	·5185	7·309	·5370	7·815	·5556	8·346	·5741	8·901	16
17	·5185	7·370	·5370	7·864	·5556	8·383	·5741	8·926	·5926	9·494	17
18	·5370	7·938	·5556	8·444	·5741	8·975	·5926	9·531	·6111	10·111	18
19	·5556	8·531	·5741	9·049	·5926	9·593	·6111	10·160	·6296	10·753	19
20	·5741	9·148	·5926	9·679	·6111	10·235	·6296	10·815	·6481	11·420	20
21	·5926	9·790	·6111	10·333	·6296	10·901	·6481	11·494	·6667	12·111	21
22	·6111	10·457	·6296	11·012	·6481	11·593	·6667	12·198	·6852	12·827	22
23	·6296	11·148	·6481	11·716	·6667	12·309	·6852	12·926	·7037	13·568	23
24	·6481	11·864	·6667	12·444	·6852	13·049	·7037	13·679	·7222	14·333	24
25	·6667	12·605	·6852	13·198	·7037	13·815	·7222	14·457	·7407	15·123	25
26	·6852	13·370	·7037	13·975	·7222	14·605	·7407	15·259	·7593	15·938	26
27	·7037	14·160	·7222	14·778	·7407	15·420	·7593	16·086	·7778	16·778	27
28	·7222	14·975	·7407	15·605	·7593	16·259	·7778	16·938	·7963	17·642	28
29	·7407	15·815	·7593	16·457	·7778	17·123	·7963	17·815	·8148	18·531	29
30	·7593	16·679	·7778	17·333	·7963	18·012	·8148	18·716	·8333	19·444	30
31	·7778	17·568	·7963	18·235	·8148	18·926	·8333	19·642	·8519	20·383	31
32	·7963	18·481	·8148	19·160	·8333	19·864	·8519	20·593	·8704	21·346	32
33	·8148	19·420	·8333	20·111	·8519	20·827	·8704	21·568	·8889	22·333	33
34	·8333	20·383	·8519	21·086	·8704	21·815	·8889	22·568	·9074	23·346	34
35	·8519	21·370	·8704	22·086	·8889	22·827	·9074	23·593	·9259	24·383	35
36	·8704	22·383	·8889	23·111	·9074	23·864	·9259	24·642	·9444	25·444	36
37	·8889	23·420	·9074	24·160	·9259	24·926	·9444	25·716	·9630	26·531	37
38	·9074	24·481	·9259	25·235	·9444	26·012	·9630	26·815	·9815	27·642	38
39	·9259	25·568	·9444	26·333	·9630	27·123	·9815	27·938	1·0000	28·778	39
40	·9444	26·679	·9630	27·457	·9815	28·259	1·0000	29·086	1·0185	29·938	40

TABLE LX.—Base 1.—Slopes 1 to 1.

Feet.	16		17		18		19		20		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2963	3·160	·3148	3·568	·3333	4·000	·3519	4·457	·3704	4·938	0
1	·3148	3·370	·3333	3·790	·3519	4·234	·3704	4·704	·3889	5·198	1
2	·3333	3·605	·3519	4·037	·3704	4·494	·3889	4·975	·4074	5·481	2
3	·3519	3·864	·3704	4·309	·3889	4·778	·4074	5·272	·4259	5·790	3
4	·3704	4·148	·3889	4·605	·4074	5·086	·4259	5·593	·4444	6·123	4
5	·3889	4·457	·4074	4·926	·4259	5·420	·4444	5·938	·4630	6·481	5
6	·4074	4·790	·4259	5·272	·4444	5·778	·4630	6·309	·4815	6·864	6
7	·4259	5·148	·4444	5·642	·4630	6·160	·4815	6·704	·5000	7·272	7
8	·4444	5·531	·4630	6·037	·4815	6·568	·5000	7·123	·5185	7·704	8
9	·4630	5·938	·4815	6·457	·5000	7·000	·5185	7·568	·5370	8·160	9
10	·4815	6·370	·5000	6·901	·5185	7·457	·5370	8·037	·5556	8·642	10
11	·5000	6·827	·5185	7·370	·5370	7·938	·5556	8·531	·5741	9·148	11
12	·5185	7·309	·5370	7·864	·5556	8·444	·5741	9·049	·5926	9·679	12
13	·5370	7·815	·5556	8·383	·5741	8·975	·5926	9·593	·6111	10·235	13
14	·5556	8·346	·5741	8·926	·5926	9·531	·6111	10·160	·6296	10·815	14
15	·5741	8·901	·5926	9·494	·6111	10·111	·6296	10·753	·6481	11·420	15
16	·5926	9·481	·6111	10·086	·6296	10·716	·6481	11·370	·6667	12·049	16
17	·6111	10·086	·6296	10·704	·6481	11·346	·6667	12·012	·6852	12·704	17
18	·6296	10·716	·6481	11·346	·6667	12·000	·6852	12·679	·7037	13·383	18
19	·6481	11·370	·6667	12·012	·6852	12·679	·7037	13·370	·7222	14·086	19
20	·6667	12·049	·6852	12·704	·7037	13·383	·7222	14·086	·7407	14·815	20
21	·6852	12·753	·7037	13·420	·7222	14·111	·7407	14·827	·7593	15·568	21
22	·7037	13·481	·7222	14·160	·7407	14·864	·7593	15·593	·7778	16·346	22
23	·7222	14·235	·7407	14·926	·7593	15·642	·7778	16·383	·7963	17·148	23
24	·7407	15·012	·7593	15·716	·7778	16·444	·7963	17·198	·8148	17·975	24
25	·7593	15·815	·7778	16·531	·7963	17·272	·8148	18·037	·8333	18·827	25
26	·7778	16·642	·7963	17·370	·8148	18·123	·8333	18·901	·8519	19·704	26
27	·7963	17·494	·8148	18·235	·8333	19·000	·8519	19·790	·8704	20·605	27
28	·8148	18·370	·8333	19·123	·8519	19·901	·8704	20·704	·8889	21·531	28
29	·8333	19·272	·8519	20·037	·8704	20·827	·8889	21·642	·9074	22·481	29
30	·8519	20·198	·8704	20·975	·8889	21·778	·9074	22·605	·9259	23·457	30
31	·8704	21·148	·8889	21·938	·9074	22·753	·9259	23·593	·9444	24·457	31
32	·8889	22·123	·9074	22·926	·9259	23·753	·9444	24·605	·9630	25·481	32
33	·9074	23·123	·9259	23·938	·9444	24·778	·9630	25·642	·9815	26·531	33
34	·9259	24·148	·9444	24·975	·9630	25·827	·9815	26·704	1·0000	27·605	34
35	·9444	25·198	·9630	26·037	·9815	26·901	1·0000	27·790	1·0185	28·704	35
36	·9630	26·272	·9815	27·123	1·0000	28·000	1·0185	28·901	1·0370	29·827	36
37	·9815	27·370	1·0000	28·235	1·0185	29·123	1·0370	30·037	1·0556	30·975	37
38	1·0000	28·494	1·0185	29·370	1·0370	30·272	1·0556	31·198	1·0741	32·148	38
39	1·0185	29·642	1·0370	30·531	1·0556	31·444	1·0741	32·383	1·0926	33·346	39
40	1·0370	30·815	1·0556	31·716	1·0741	32·642	1·0926	33·593	1·1111	34·568	40

TABLE LXI.—Base 1.—Slopes 1 to 1.

Feet.	21		22		23		24		25		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·3889	5·444	·4074	5·975	·4259	6·531	·4444	7·111	·4630	7·716	0
1	·4074	5·716	·4259	6·259	·4444	6·827	·4630	7·420	·4815	8·037	1
2	·4259	6·012	·4444	6·568	·4630	7·148	·4815	7·753	·5000	8·383	2
3	·4444	6·333	·4630	6·901	·4815	7·494	·5000	8·111	·5185	8·753	3
4	·4630	6·679	·4815	7·259	·5000	7·864	·5185	8·494	·5370	9·148	4
5	·4815	7·049	·5000	7·642	·5185	8·259	·5370	8·901	·5556	9·568	5
6	·5000	7·444	·5185	8·049	·5370	8·679	·5556	9·333	·5741	10·012	6
7	·5185	7·864	·5370	8·481	·5556	9·123	·5741	9·790	·5926	10·481	7
8	·5370	8·309	·5556	8·938	·5741	9·593	·5926	10·272	·6111	10·975	8
9	·5556	8·778	·5741	9·420	·5926	10·086	·6111	10·778	·6296	11·494	9
10	·5741	9·272	·5926	9·926	·6111	10·605	·6296	11·309	·6481	12·037	10
11	·5926	9·790	·6111	10·457	·6296	11·148	·6481	11·864	·6667	12·605	11
12	·6111	10·333	·6296	11·012	·6481	11·716	·6667	12·444	·6852	13·198	12
13	·6296	10·901	·6481	11·593	·6667	12·309	·6852	13·049	·7037	13·815	13
14	·6481	11·494	·6667	12·198	·6852	12·926	·7037	13·679	·7222	14·457	14
15	·6667	12·111	·6852	12·827	·7037	13·568	·7222	14·333	·7407	15·123	15
16	·6852	12·753	·7037	13·481	·7222	14·235	·7407	15·012	·7593	15·815	16
17	·7037	13·420	·7222	14·160	·7407	14·926	·7593	15·716	·7778	16·531	17
18	·7222	14·111	·7407	14·864	·7593	15·642	·7778	16·444	·7963	17·272	18
19	·7407	14·827	·7593	15·593	·7778	16·383	·7963	17·198	·8148	18·037	19
20	·7593	15·568	·7778	16·346	·7963	17·148	·8148	17·975	·8333	18·827	20
21	·7778	16·333	·7963	17·123	·8148	17·938	·8333	18·778	·8519	19·642	21
22	·7963	17·123	·8148	17·926	·8333	18·753	·8519	19·605	·8704	20·481	22
23	·8148	17·938	·8333	18·753	·8519	19·593	·8704	20·457	·8889	21·346	23
24	·8333	18·778	·8519	19·605	·8704	20·457	·8889	21·333	·9074	22·235	24
25	·8519	19·642	·8704	20·481	·8889	21·346	·9074	22·235	·9259	23·148	25
26	·8704	20·531	·8889	21·383	·9074	22·259	·9259	23·160	·9444	24·086	26
27	·8889	21·444	·9074	22·309	·9259	23·198	·9444	24·111	·9630	25·049	27
28	·9074	22·383	·9259	23·259	·9444	24·160	·9630	25·086	·9815	26·037	28
29	·9259	23·346	·9444	24·235	·9630	25·148	·9815	26·086	1·0000	27·049	29
30	·9444	24·333	·9630	25·235	·9815	26·160	1·0000	27·111	1·0185	28·086	30
31	·9630	25·346	·9815	26·259	1·0000	27·198	1·0185	28·160	1·0370	29·148	31
32	·9815	26·383	1·0000	27·309	1·0185	28·259	1·0370	29·235	1·0556	30·235	32
33	1·0000	27·444	1·0185	28·383	1·0370	29·346	1·0556	30·333	1·0741	31·346	33
34	1·0185	28·531	1·0370	29·481	1·0556	30·457	1·0741	31·457	1·0926	32·481	34
35	1·0370	29·642	1·0556	30·605	1·0741	31·593	1·0926	32·605	1·1111	33·642	35
36	1·0556	30·778	1·0741	31·753	1·0926	32·753	1·1111	33·778	1·1296	34·827	36
37	1·0741	31·938	1·0926	32·926	1·1111	33·938	1·1296	34·975	1·1481	36·037	37
38	1·0926	33·123	1·1111	34·123	1·1296	35·148	1·1481	36·198	1·1667	37·272	38
39	1·1111	34·333	1·1296	35·346	1·1481	36·383	1·1667	37·444	1·1852	38·531	39
40	1·1296	35·568	1·1481	36·593	1·1667	37·642	1·1852	38·716	1·2047	39·815	40

TABLE LXII.—Base 1.—Slopes 1 to 1.

Feet.	26		27		28		29		30		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·4815	8·346	·5000	9·000	·5185	9·679	·5370	10·383	·5556	11·111	0
1	·5000	8·679	·5185	9·346	·5370	10·037	·5556	10·753	·5741	11·494	1
2	·5185	9·037	·5370	9·716	·5556	10·420	·5741	11·148	·5926	11·901	2
3	·5370	9·420	·5556	10·111	·5741	10·827	·5926	11·568	·6111	12·333	3
4	·5556	9·827	·5741	10·531	·5926	11·259	·6111	12·012	·6296	12·790	4
5	·5741	10·259	·5926	10·975	·6111	11·716	·6296	12·481	·6481	13·272	5
6	·5926	10·716	·6111	11·444	·6296	12·198	·6481	12·975	·6667	13·778	6
7	·6111	11·198	·6296	11·938	·6481	12·704	·6667	13·494	·6852	14·309	7
8	·6296	11·704	·6481	12·457	·6667	13·235	·6852	14·037	·7037	14·864	8
9	·6481	12·235	·6667	13·000	·6852	13·790	·7037	14·605	·7222	15·444	9
10	·6667	12·790	·6852	13·568	·7037	14·370	·7222	15·198	·7407	16·049	10
11	·6852	13·370	·7037	14·160	·7222	14·975	·7407	15·815	·7593	16·679	11
12	·7037	13·975	·7222	14·778	·7407	15·605	·7593	16·457	·7778	17·333	12
13	·7222	14·605	·7407	15·420	·7593	16·259	·7778	17·123	·7963	18·012	13
14	·7407	15·259	·7593	16·086	·7778	16·938	·7963	17·815	·8148	18·716	14
15	·7593	15·938	·7778	16·778	·7963	17·642	·8148	18·531	·8333	19·444	15
16	·7778	16·642	·7963	17·494	·8148	18·370	·8333	19·272	·8519	20·198	16
17	·7963	17·370	·8148	18·235	·8333	19·123	·8519	20·037	·8704	20·975	17
18	·8148	18·123	·8333	19·000	·8519	19·901	·8704	20·827	·8889	21·778	18
19	·8333	18·901	·8519	19·790	·8704	20·704	·8889	21·642	·9074	22·605	19
20	·8519	19·704	·8704	20·605	·8889	21·531	·9074	22·481	·9259	23·457	20
21	·8704	20·531	·8889	21·444	·9074	22·383	·9259	23·346	·9444	24·333	21
22	·8889	21·383	·9074	22·309	·9259	23·259	·9444	24·235	·9630	25·235	22
23	·9074	22·259	·9259	23·198	·9444	24·160	·9630	25·148	·9815	26·160	23
24	·9259	23·160	·9444	24·111	·9630	25·086	·9815	26·086	1·0000	27·111	24
25	·9444	24·086	·9630	25·049	·9815	26·037	1·0000	27·049	1·0185	28·086	25
26	·9630	25·037	·9815	26·012	1·0000	27·012	1·0185	28·037	1·0370	29·086	26
27	·9815	26·012	1·0000	27·000	1·0185	28·012	1·0370	29·049	1·0556	30·111	27
28	1·0000	27·012	1·0185	28·012	1·0370	29·037	1·0556	30·086	1·0741	31·160	28
29	1·0185	28·037	1·0370	29·049	1·0556	30·086	1·0741	31·148	1·0926	32·235	29
30	1·0370	29·086	1·0556	30·111	1·0741	31·160	1·0926	32·235	1·1113	33·333	30
31	1·0556	30·160	1·0741	31·198	1·0626	32·259	1·1111	33·346	1·1296	34·457	31
32	1·0741	31·259	1·0926	32·309	1·1111	33·383	1·1296	34·481	1·1481	35·605	32
33	1·0926	32·383	1·1111	33·444	1·1296	34·531	1·1481	35·642	1·1667	36·778	33
34	1·1111	33·531	1·1296	34·605	1·1481	35·704	1·1667	36·827	1·1852	37·975	34
35	1·1296	34·704	1·1481	35·790	1·1667	36·901	1·1852	38·037	1·2047	39·198	35
36	1·1481	35·901	1·1667	37·000	1·1852	38·123	1·2047	39·272	1·2222	40·444	36
37	1·1667	37·123	1·1852	38·235	1·2047	39·370	1·2222	40·531	1·2407	41·716	37
38	1·1852	38·370	1·2047	39·494	1·2222	40·642	1·2407	41·815	1·2593	43·012	38
39	1·2047	39·642	1·2222	40·778	1·2407	41·938	1·2593	43·123	1·2778	44·333	39
40	1·2222	40·938	1·2407	42·086	1·2593	43·259	1·2778	44·457	1·2963	45·679	40

TABLE LXIII.—Base 1.—Slopes 1 to 1.

Feet.	31		32		33		34		35		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·5741	11·864	·5926	12·642	·6111	13·444	·6296	14·272	·6481	15·123	0
1	·5926	12·259	·6111	13·049	·6296	13·864	·6481	14·704	·6667	15·568	1
2	·6111	12 679	·6296	13·481	·6481	14·309	·6667	15·160	·6852	16·037	2
3	·6296	13·123	·6481	13·938	·6667	14·778	·6852	15·642	·7037	16·531	3
4	·6481	13·593	·6667	14·420	·6852	15·272	·7037	16·148	·7222	17·049	4
5	·6667	14·086	·6852	14·926	·7037	15·790	·7222	16·679	·7407	17·593	5
6	·6852	14·605	·7037	15·457	·7222	16·333	·7407	17·235	·7593	18·160	6
7	·7037	15·148	·7222	16·012	·7407	16·901	·7593	17·815	·7778	18·753	7
8	·7222	15·716	·7407	16·593	·7593	17·494	·7778	18·420	·7963	19·370	8
9	·7407	16·309	·7593	17·198	·7778	18·111	·7963	19·049	·8148	20·012	9
10	·7593	16·926	·7778	17·827	·7963	18·753	·8148	19·704	·8333	20·679	10
11	·7778	17·568	·7963	18·481	·8148	19·420	·8333	20·383	·8519	21·370	11
12	·7963	18·235	·8148	19·160	·8333	20·111	·8519	21·086	·8704	22·086	12
13	·8148	18·926	·8333	19·864	·8519	20·827	·8704	21·815	·8889	22·827	13
14	·8333	19·642	·8519	20·593	·8704	21·568	·8889	22·568	·9074	23·593	14
15	·8519	20·383	·8704	21·346	·8889	22·333	·9074	23·346	·9259	24·383	15
16	·8704	21·148	·8889	22·123	·9074	23·123	·9259	24·148	·9444	25·198	16
17	·8889	21·938	·9074	22·926	·9259	23·938	·9444	24·975	·9630	26·037	17
18	·9074	22·753	·9259	23·753	·9444	24·778	·9630	25·827	·9815	26·901	18
19	·9259	23·593	·9444	24·605	·9630	25·642	·9815	26·704	1·0000	27·790	19
20	·9444	24·457	·9630	25·481	·9815	26·531	1·0000	27·605	1·0185	28·704	20
21	·9630	25·346	·9815	26·383	1·0000	27·444	1·0185	28·531	1·0370	29·642	21
22	·9815	26·259	1·0000	27·309	1·0185	28·383	1·0370	29·481	1·0556	30·605	22
23	1·0000	27·198	1·0185	28·259	1·0370	29·346	1·0556	30·457	1·0741	31·593	23
24	1·0185	28·160	1·0370	29·235	1·0556	30·333	1·0741	31·457	1·0926	32·605	24
25	1·0370	29·148	1·0556	30·235	1·0741	31·346	1·0926	32·481	1·1111	33·642	25
26	1·0556	30·160	1·0741	31·259	1·0926	32·383	1·1111	33·531	1·1296	34·704	26
27	1·0741	31·198	1·0926	32·309	1·1111	33·444	1·1296	34·605	1·1481	35·790	27
28	1·0926	32·259	1·1111	33·383	1·1296	34·531	1·1481	35·704	1·1667	36·901	28
29	1·1111	33·346	1·1296	34·481	1·1481	35·642	1·1667	36·827	1·1852	38·037	29
30	1·1296	34·457	1·1481	35 605	1·1667	36·778	1·1852	37·975	1·2047	39·198	30
31	1·1481	35·593	1·1667	36·753	1·1852	37·938	1·2047	39·148	1·2222	40·383	31
32	1·1667	36·753	1·1852	37·926	1·2047	39·123	1·2222	40·346	1·2407	41·593	32
33	1·1852	37·938	1·2047	39·123	1·2222	40·333	1·2407	41·568	1·2593	42·827	33
34	1·2047	39·148	1·2222	40·346	1·2407	41·568	1·2593	42·815	1·2778	44·086	34
35	1·2222	40·383	1·2407	41·593	1·2593	42·827	1·2778	44·086	1·2963	45·370	35
36	1·2407	41·642	1·2593	42·864	1·2778	44·111	1·2963	45·383	1·3148	46·679	36
37	1·2593	42·926	1·2778	44·160	1·2963	45·420	1·3148	46·704	1·3333	48·012	37
38	1·2778	44·235	1·2963	45·481	1·3148	46·753	1·3333	48·049	1·3519	49·370	38
39	1·2963	45·568	1·3148	46·827	1·3333	48·111	1·3519	49·420	1·3704	50·753	39
40	1·3148	46·926	1·3333	48·198	1·3519	49·494	1·3704	50·815	1·3889	52·160	40

TABLE LXIV.—Base 1.—Slopes $1\frac{1}{2}$ to 1.

Feet.	36		37		38		39		40		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·6667	16·000	·6852	16·901	·7037	17·827	·7222	18·778	·7407	19·753	0
1	·6852	16·457	·7037	17·370	·7222	18·309	·7407	19·272	·7593	20·259	1
2	·7037	16·938	·7222	17·864	·7407	18·815	·7593	19·790	·7778	20·790	2
3	·7222	17·444	·7407	18·383	·7593	19·346	·7778	20·333	·7963	21·346	3
4	·7407	17·975	·7593	18·926	·7778	19·901	·7963	20·901	·8148	21·926	4
5	·7593	18·531	·7778	19·494	·7963	20·481	·8148	21·494	·8333	22·531	5
6	·7778	19·111	·7963	20·086	·8148	21·086	·8333	22·111	·8519	23·160	6
7	·7963	19·716	·8148	20·704	·8333	21·716	·8519	22·753	·8704	23·815	7
8	·8148	20·346	·8333	21·346	·8519	22·370	·8704	23·420	·8889	24·494	8
9	·8333	21·000	·8519	22·012	·8704	23·049	·8889	24·111	·9074	25·198	9
10	·8519	21·679	·8704	22·704	·8889	23·753	·9074	24·847	·9259	25·926	10
11	·8704	22·383	·8889	23·420	·9074	24·481	·9259	25·568	·9444	26·679	11
12	·8889	23·111	·9074	24·160	·9259	25·235	·9444	26·333	·9630	27·457	12
13	·9074	23·864	·9259	24·926	·9444	26·012	·9630	27·123	·9815	28·259	12
14	·9259	24·642	·9444	25·716	·9630	26·815	·9815	27·938	1·0000	29·086	14
15	·9444	25·444	·9630	26·531	·9815	27·642	1·0000	28·778	1·0185	29·938	15
16	·9630	26·272	·9815	27·370	1·0000	28·494	1·0185	29·642	1·0370	30·815	16
17	·9815	27·123	1·0000	28·235	1·0185	29·370	1·0370	30·531	1·0556	31·716	17
18	1·0000	28·000	1·0185	29·123	1·0370	30·272	1·0556	31·444	1·0741	32·642	18
19	1·0185	28·901	1·0370	30·037	1·0556	31·198	1·0741	32·383	1·0926	33·593	19
20	1·0370	29·827	1·0556	30·975	1·0741	32·148	1·0926	33·346	1·1111	34·568	20
21	1·0556	30·778	1·0741	31·938	1·0926	33·123	1·1111	34·333	1·1296	35·568	21
22	1·0741	31·753	1·0926	32·926	1·1111	34·123	1·1296	35·346	1·1481	36·593	22
23	1·0926	32·753	1·1111	33·938	1·1296	35·148	1·1481	36·383	1·1667	37·642	23
24	1·1111	33·778	1·1296	34·975	1·1481	36·198	1·1667	37·444	1·1852	38·716	24
25	1·1296	34·827	1·1481	36·037	1·1667	37·272	1·1852	38·531	1·2047	39·815	25
26	1·1481	35·901	1·1667	37·123	1·1852	38·370	1·2047	39·642	1·2222	40·938	26
27	1·1667	37·000	1·1852	38·235	1·2047	39·494	1·2222	40·778	1·2407	42·086	27
28	1·1852	38·123	1·2047	39·370	1·2222	40·642	1·2407	41·938	1·2593	43·259	28
29	1·2047	39·272	1·2222	40·531	1·2407	41·815	1·2593	43·123	1·2778	44·457	29
30	1·2222	40·444	1·2407	41·716	1·2593	43·012	1·2778	44·333	1·2963	45·679	30
31	1·2407	41·642	1·2593	42·926	1·2778	44·235	1·2963	45·568	1·3148	46·926	31
32	1·2593	42·864	1·2778	44·160	1·2963	45·481	1·3148	46·827	1·3333	48·198	32
33	1·2778	44·111	1·2963	45·420	1·3148	46·753	1·3333	48·111	1·3519	49·494	33
34	1·2963	45·383	1·3148	46·704	1·3333	48·049	1·3519	49·420	1·3704	50·815	34
35	1·3148	46·679	1·3333	48·012	1·3519	49·370	1·3704	50·753	1·3889	52·160	35
36	1·3333	48·000	1·3519	49·346	1·3704	50·716	1·3889	52·111	1·4074	53·531	36
37	1·3519	49·346	1·3704	50·704	1·3889	52·086	1·4074	53·494	1·4259	54·926	37
38	1·3704	50·716	1·3889	52·086	1·4074	53·481	1·4259	54·901	1·4444	56·346	38
39	1·3889	52·111	1·4074	53·494	1·4259	54·901	1·4444	56·333	1·4630	57·790	39
40	1·4074	53·531	1·4259	54·926	1·4444	56·346	1·4630	57·790	1·4815	59·259	40

TABLE LXV.—Base 1.—Slopes 1½ to 1.

Feet.	1		2		3		4		5		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·0185	·019	·0370	·074	·0556	·167	·0741	·296	·0926	·463	0
1	·0370	·056	·0556	·130	·0741	·241	·0926	·389	·1111	·574	1
2	·0556	·130	·0741	·222	·0926	·352	·1111	·519	·1296	·722	2
3	·0741	·241	·0926	·352	·1111	·500	·1296	·685	·1481	·907	3
4	·0926	·389	·1111	·519	·1296	·685	·1481	·889	·1667	1·130	4
5	·1111	·574	·1296	·722	·1481	·907	·1667	1·130	·1852	1·389	5
6	·1296	·796	·1481	·963	·1667	1·167	·1852	1·407	·2037	1·685	6
7	·1481	1·056	·1667	1·241	·1852	1·463	·2037	1·722	·2222	2·019	7
8	·1667	1·352	·1852	1·556	·2037	1·796	·2222	2·074	·2407	2·389	8
9	·1852	1·685	·2037	1·907	·2222	2·167	·2407	2·463	·2593	2·796	9
0	·2037	2·056	·2222	2·296	·2407	2·574	·2593	2·889	·2778	3·241	10
11	·2222	2·463	·2407	2·722	·2593	3·019	·2778	3·352	·2963	3·722	11
12	·2407	2·907	·2593	3·185	·2778	3·500	·2963	3·852	·3148	4·241	12
13	·2593	3·389	·2778	3·685	·2963	4·019	·3148	4·389	·3333	4·796	13
14	·2778	3·907	·2963	4·222	·3148	4·574	·3333	4·963	·3519	5·389	14
15	·2963	4·463	·3148	4·796	·3333	5·167	·3519	5·574	·3704	6·019	15
16	·3148	5·056	·3333	5·407	·3519	5·796	·3704	6·222	·3889	6·685	16
17	·3333	5·685	·3519	6·056	·3704	6·463	·3889	6·907	·4074	7·389	17
18	·3519	6·352	·3704	6·741	·3889	7·167	·4074	7·630	·4259	8·130	18
19	·3704	7·056	·3889	7·463	·4074	7·907	·4259	8·389	·4444	8·907	19
20	·3889	7·796	·4074	8·222	·4259	8·685	·4444	9·185	·4630	9·722	20
21	·4074	8·574	·4259	9·019	·4444	9·500	·4630	10·019	·4815	10·574	21
22	·4259	9·389	·4444	9·852	·4630	10·352	·4815	10·889	·5000	11·463	22
23	·4444	10·241	·4630	10·722	·4815	11·241	·5000	11·796	·5185	12·389	23
24	·4630	11·130	·4815	11·630	·5000	12·167	·5185	12·741	·5370	13·352	24
25	·4815	12·056	·5000	12·574	·5185	13·130	·5370	13·722	·5556	14·352	25
26	·5000	13·019	·5185	13·556	·5370	14·130	·5556	14·741	·5741	15·389	26
27	·5185	14·019	·5370	14·574	·5556	15·167	·5741	15·796	·5926	16·463	27
28	·5370	15·056	·5556	15·630	·5741	16·241	·5926	16·889	·6111	17·574	28
29	·5556	16·130	·5741	16·722	·5926	17·352	·6111	18·019	·6296	18·722	29
30	·5741	17·241	·5926	17·852	·6111	18·500	·6296	19·185	·6481	19·907	30
31	·5926	18·389	·6111	19·019	·6296	19·685	·6481	20·389	·6667	21·130	31
32	·6111	19·574	·6296	20·222	·6481	20·907	·6667	21·630	·6852	22·389	32
33	·6296	20·796	·6481	21·463	·6667	22·167	·6852	22·907	·7037	23·685	33
34	·6481	22·056	·6667	22·741	·6852	23·463	·7037	24·222	·7222	25·019	34
35	·6667	23·352	·6852	24·056	·7037	24·796	·7222	25·574	·7407	26·389	35
36	·6852	24·685	·7037	25·407	·7222	26·167	·7407	26·963	·7593	27·796	36
37	·7037	26·056	·7222	26·796	·7407	27·574	·7593	28·389	·7778	29·241	37
38	·7222	27·463	·7407	28·222	·7593	29·019	·7778	29·852	·7693	30·722	38
39	·7407	28·907	·7593	29·685	·7778	30·500	·7963	31·352	·8148	32·241	39
40	·7593	30·389	·7778	31·185	·7963	32·019	·8148	32·889	·8333	33·796	40

TABLE LXVI.—Base 1.—Slopes 1½ to 1.

Feet.	6		7		8		9		10		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·1111	·667	·1296	·907	·1481	1·185	·1667	1·500	·1852	1·852	0
1	·1296	·796	·1481	1·056	·1667	1·352	·1852	1·685	·2037	2·056	1
2	·1481	·963	·1667	1·241	·1852	1·556	·2037	1·907	·2222	2·296	2
3	·1667	1·167	·1852	1·463	·2037	1·796	·2222	2·167	·2407	2·574	3
4	·1852	1·407	·2037	1·722	·2222	2·074	·2407	2·463	·2593	2·889	4
5	·2037	1·685	·2222	2·019	·2407	2·389	·2593	2·796	·2778	3·241	5
6	·2222	2·000	·2407	2·352	·2593	2·741	·2778	3·167	·2963	3·630	6
7	·2407	2·352	·2593	2·722	·2778	3·130	·2963	3·574	·3148	4·056	7
8	·2593	2·741	·2778	3·130	·2963	3·556	·3148	4·019	·3333	4·519	8
9	·2778	3·167	·2963	3·574	·3148	4·019	·3333	4·500	·3519	5·019	9
10	·2963	3·630	·3148	4·056	·3333	4·519	·3519	5·019	·3704	5·556	10
11	·3148	4·130	·3333	4·574	·3519	5·056	·3704	5·574	·3889	6·130	11
12	·3333	4·667	·3519	5·130	·3704	5·630	·3889	6·167	·4074	6·741	12
13	·3519	5·241	·3704	5·722	·3889	6·241	·4074	6·796	·4259	7·389	13
14	·3704	5·852	·3889	6·352	·4074	6·889	·4259	7·463	·4444	8·074	14
15	·3889	6·500	·4074	7·019	·4259	7·574	·4444	8·167	·4630	8·796	15
16	·4074	7·185	·4259	7·722	·4444	8·296	·4630	8·907	·4815	9·556	16
17	·4259	7·907	·4444	8·463	·4630	9·056	·4815	9·685	·5000	10·352	17
18	·4444	8·667	·4630	9·241	·4815	9·852	·5000	10·500	·5185	11·185	18
19	·4630	9·463	·4815	10·056	·5000	10·685	·5185	11·352	·5370	12·056	19
20	·4815	10·296	·5000	10·907	·5185	11·556	·5370	12·241	·5556	12·963	20
21	·5000	11·167	·5185	11·796	·5370	12·463	·5556	13·167	·5741	13·907	21
22	·5185	12·074	·5370	12·722	·5556	13·407	·5741	14·130	·5926	14·889	22
23	·5370	13·019	·5556	13·685	·5741	14·389	·5926	15·130	·6111	15·907	23
24	·5556	14·000	·5741	14·685	·5926	15·407	·6111	16·167	·6296	16·963	24
25	·5741	15·019	·5926	15·722	·6111	16·463	·6296	17·241	·6481	18·056	25
26	·5926	16·074	·6111	16·796	·6296	17·556	·6481	18·352	·6667	19·185	26
27	·6111	17·167	·6296	17·907	·6481	18·685	·6667	19·500	·6852	20·352	27
28	·6296	18·296	·6481	19·056	·6667	19·852	·6852	20·685	·7037	21·556	28
29	·6481	19·463	·6667	20·241	·6852	21·056	·7037	21·907	·7222	22·796	29
30	·6667	20·667	·6852	21·463	·7037	22·296	·7222	23·167	·7407	24·074	30
31	·6852	21·907	·7037	22·722	·7222	23·574	·7407	24·463	·7593	25·389	31
32	·7037	23·185	·7222	24·019	·7407	24·889	·7593	25·796	·7778	26·741	32
33	·7222	24·500	·7407	25·352	·7593	26·241	·7778	27·167	·7963	28·130	33
34	·7407	25·852	·7593	26·722	·7778	27·630	·7963	28·574	·8148	29·556	34
35	·7593	27·241	·7778	28·130	·7963	29·056	·8148	30·019	·8333	31·019	35
36	·7778	28·667	·7963	29·574	·8148	30·519	·8333	31·500	·8519	32·519	36
37	·7973	30·130	·8148	31·056	·8333	32·019	·8519	33·019	·8704	34·056	37
38	·8148	31·630	·8333	32·574	·8519	33·556	·8704	34·574	·8889	35·630	38
39	·8333	33·167	·8519	34·130	·8704	35·130	·8889	36·167	·9074	37·241	39
40	·8519	34·741	·8704	35·722	·8889	36·741	·9074	37·796	·9259	38·889	40

TABLE LXVII.—Base 1—Slopes 1½ to 1.

Feet.	11		12		13		14		15		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2037	2·241	·2222	2·667	·2407	3·130	·2593	3·630	·2778	4·167	0
1	·2222	2·463	·2407	2·907	·2593	3·389	·2778	3·907	·2963	4·463	1
2	·2407	2·722	·2593	3·185	·2778	3·685	·2963	4·222	·3148	4·796	2
3	·2593	3·019	·2778	3·500	·2963	4·019	·3148	4·574	·3333	5·167	3
4	·2778	3·352	·2963	3·852	·3148	4·389	·3333	4·963	·3519	5·574	4
5	·2963	3·722	·3148	4·241	·3333	4·796	·3519	5·389	·3704	6·019	5
6	·3148	4·130	·3333	4·667	·3519	5·241	·3704	5·852	·3889	6·500	6
7	·3333	4·574	·3519	5·130	·3704	5·722	·3889	6·352	·4074	7·019	7
8	·3519	5·056	·3704	5·630	·3889	6·241	·4074	6·889	·4259	6·574	8
9	·3704	5·574	·3889	6·167	·4074	6·796	·4259	7·463	·4444	8·167	9
10	·3889	6·130	·4074	6·741	·4259	7·389	·4444	8·074	·4630	8·796	10
11	·4074	6·722	·4259	7·352	·4444	8·019	·4630	8·722	·4815	9·463	11
12	·4259	7·352	·4444	8·000	·4630	8·685	·4815	9·407	·5000	10·167	12
13	·4444	8·019	·4630	8·685	·4815	9·389	·5000	10·130	·5185	10·907	13
14	·4630	8·722	·4815	9·407	·5000	10·130	·5185	10·889	·5370	11·685	14
15	·4815	9·463	·5000	10·167	·5185	10·907	·5370	11·685	·5556	12·500	15
16	·5000	10·241	·5185	10·963	·5370	11·722	·5556	12·519	·5741	13·352	16
17	·5185	11·056	·5370	11·796	·5556	12·574	·5741	13·389	·5926	14·241	17
18	·5370	11·907	·5556	12·667	·5741	13·463	·5926	14·296	·6111	15·167	18
19	·5556	12·796	·5741	13·574	·5926	14·389	·6111	15·241	·6296	16·130	19
20	·5741	13·722	·5926	14·519	·6111	15·352	·6296	16·222	·6481	17·130	20
21	·5926	14·685	·6111	15·500	·6296	16·352	·6481	17·241	·6667	18·167	21
22	·6111	15·685	·6296	16·519	·6481	17·389	·6667	18·296	·6852	19·241	22
23	·6296	16·722	·6481	17·574	·6667	18·463	·6852	19·389	·7037	20·352	23
24	·6481	17·796	·6667	18·667	·6852	19·574	·7037	20·519	·7222	21·500	24
25	·6667	18·907	·6852	19·796	·7037	20·722	·7222	21·685	·7407	22·685	25
26	·6852	20·056	·7037	20·963	·7222	21·907	·7407	22·889	·7593	23·907	26
27	·7037	21·241	·7222	22·167	·7407	23·130	·7593	24·130	·7778	25·167	27
28	·7222	22·463	·7407	23·407	·7593	24·389	·7778	25·407	·7963	26·463	28
29	·7407	23·722	·7593	24·685	·7778	25·685	·7963	26·722	·8148	27·796	29
30	·7593	25·019	·7778	26·000	·7963	27·019	·8148	28·074	·8333	29·167	30
31	·7778	26·352	·7963	27·352	·8148	28·389	·8333	29·463	·8519	30·574	31
32	·7963	27·722	·8148	28·741	·8333	29·796	·8519	30·889	·8704	32·019	32
33	·8148	29·130	·8333	30·167	·8519	31·241	·8704	32·352	·8889	33·500	33
34	·8333	30·574	·8519	31·630	·8704	32·722	·8889	33·852	·9074	35·019	34
35	·8519	32·056	·8704	33·130	·8889	34·241	·9074	35·389	·9259	36·574	35
36	·8704	33·574	·8889	34·667	·9074	35·796	·9259	36·963	9·444	38·167	36
37	·8889	35·130	·9074	36·241	·9259	37·389	·9444	38·574	9·630	39·796	37
38	·9074	36·722	·9259	37·852	·9444	39·019	·9630	40·222	9·815	41·463	38
39	·9259	38·352	·9444	39·500	·9630	40·685	·9815	41·907	1·0000	43·167	39
40	·9444	40·019	·9630	41·185	·9815	42·389	1·0000	43·630	1·0185	44·907	40

TABLE LXVIII—Base 1—Slopes 1½ to 1.

Feet.	16		17		18		19		20		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2963	4·741	·3148	5·352	·3333	6·000	·3519	6·685	·3704	7·407	0
1	·3148	5·056	·3333	5·685	·3519	6·352	·3704	7·056	·3889	7·796	1
2	·3333	5·407	·3519	6·056	·3704	6·741	·3889	7·463	·4074	8·222	2
3	·3519	5·796	·3704	6·463	·3889	7·167	·4074	7·907	·4259	8·685	3
4	·3704	6·222	·3889	6·907	·4074	7·630	·4259	8·389	·4444	9·185	4
5	·3889	6·685	·4074	7·389	·4259	8·130	·4444	8·907	·4630	9·722	5
6	·4074	7·185	·4259	7·907	·4444	8·667	·4630	9·463	·4815	10·296	6
7	·4259	7·722	·4444	8·463	·4630	9·241	·4815	10·056	·5000	10·907	7
8	·4444	8·296	·4630	9·056	·4815	9·852	·5000	10·685	·5185	11·556	8
9	·4630	8·907	·4815	9·685	·5000	10·500	·5185	11·352	·5370	12·241	9
10	·4815	9·556	·5000	10·352	·5185	11·185	·5370	12·056	·5556	12·963	10
11	·5000	10·241	·5185	11·056	·5370	11·907	·5556	12·796	·5741	13·722	11
12	·5185	10·963	·5370	11·796	·5556	12·667	·5741	13·574	·5926	14·519	12
13	·5370	11·722	·5556	12·574	·5741	13·463	·5926	14·389	·6111	15·352	13
14	·5556	12·519	·5741	13·389	·5926	14·296	·6111	15·241	·6296	16·222	14
15	·5741	13·352	·5926	14·241	·6111	15·167	·6296	16·130	·6481	17·130	15
16	·5926	14·222	·6111	15·130	·6296	16·074	·6481	17·056	·6667	18·074	16
17	·6111	15·130	·6296	16·056	·6481	17·019	·6667	18·019	·6852	19·056	17
18	·6296	16·074	·6481	17·019	·6667	18·000	·6852	19·019	·7037	20·074	18
19	·6481	17·056	·6667	18·019	·6852	19·019	·7037	20·056	·7222	21·130	19
20	·6667	18·074	·6852	19·056	·7037	20·074	·7222	21·130	·7407	22·222	20
21	·6852	19·130	·7037	20·130	·7222	21·167	·7407	22·241	·7593	23·352	21
22	·7037	20·222	·7222	21·241	·7407	22·296	·7593	23.389	·7778	24·519	22
23	·7222	21·352	·7407	22·389	·7593	23·463	·7778	24·574	·7963	25·722	23
24	·7407	22·519	·7593	23·574	·7778	24·667	·7963	25·796	·8148	26·963	24
25	·7593	23·722	·7778	24·796	·7963	25·907	·8148	27·056	·8333	28·241	25
26	·7778	24·963	·7963	26·056	·8148	27·185	·8333	28·352	·8519	29·556	26
27	·7963	26·241	·8148	27·352	·8333	28·500	·8519	29·685	·8704	30·907	27
28	·8148	27·556	·8333	28·685	·8519	29·852	·8704	31·056	·8889	32·296	28
29	·8333	28·907	·8519	30·056	·8704	31·241	·8889	32·463	·9074	33·722	29
30	·8519	30·296	·8704	31·463	·8889	32·667	·9074	33·907	·9259	35·185	30
31	·8704	31·722	·8889	32·907	·9074	34·130	·9259	35·389	·9444	36·685	31
32	·8889	33·185	·9074	34·389	·9259	35·630	·9444	36·907	·9630	38·222	32
33	·9074	34·685	·9259	35·907	·9444	37·167	·9630	38·463	·9815	39·796	33
34	·9259	36·222	·9444	37·463	·9630	38·741	·9815	40·056	1·0000	41·407	34
35	·9444	37·796	·9630	39·056	·9815	40·352	1·0000	41·685	1·0185	43·056	35
36	·9630	39·407	·9815	40·685	1·0000	42·000	1·0185	43·352	1·0370	44·741	36
37	·9815	41·056	1·0000	42·352	1·0185	43·685	1·0370	45·056	1·0556	46·463	37
38	1·0000	42·741	1·0185	44·056	1·0370	45·407	1·0556	46·796	1·0741	48·222	38
39	1·0185	44·463	1·0370	45·796	1·0556	47·167	1·0741	48·574	1·0926	50·019	39
40	1·0370	46·222	1·0556	47·574	1·0741	38·963	1·0926	50·389	1·1111	51·852	40

TABLE LXIX.—Base 1—Slopes 1½ to 1.

Feet.	21		22		23		24		25		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·3889	8·167	·4047	8·963	·4259	9·796	·4444	10·667	·4630	11·574	0
1	·4074	8·574	·4259	9·389	·4444	10·241	·4630	11·130	·4815	12·056	1
2	·4259	9·019	·4444	9·852	·4630	10·722	·4815	11·630	·5000	12·574	2
3	·4444	9·500	·4630	10·352	·4815	11·241	·5000	12·167	·5185	13·130	3
4	·4630	10·019	·4815	10·889	·5000	11·796	·5185	12·741	·5370	13·722	4
5	·4815	10·574	·5000	11·463	·5185	12·389	·5370	13·352	·5556	14·352	5
6	·5000	11·167	·5185	12·074	·5370	13·019	·5556	14·000	·5741	15·019	6
7	·5185	11·796	·5370	12·722	·5556	13·685	·5741	14·685	·5926	15·722	7
8	·5370	12·463	·5556	13·407	·5741	14·389	·5926	15·407	·6111	16·463	8
9	·5556	13·167	·5741	14·130	·5926	15·130	·6111	16·167	·6296	17·241	9
10	·5741	13·907	·5926	14·889	·6111	15·907	·6296	16·963	·6481	18·056	10
11	·5926	14·685	·6111	15·685	·6296	16·722	·6481	17·796	·6667	18·907	11
12	·6111	15·500	·6296	16·519	·6481	17·574	·6667	18·667	·6852	19·796	12
13	·6296	16·352	·6481	17·389	·6667	18·463	·6852	19·574	·7037	20·722	13
14	·6481	17·241	·6667	18·296	·6852	19·389	·7037	20·519	·7222	21·685	14
15	·6667	18·167	·6852	19·241	·7037	20·352	·7222	21·500	·7407	22·685	15
16	·6852	19·130	·7037	20·222	·7222	21·352	·7407	22·519	·7593	23·722	16
17	·7037	20·130	·7222	21·241	·7407	22·389	·7593	23·574	·7778	24·796	17
18	·7222	21·167	·7407	22·296	·7593	23·463	·7778	24·667	·7963	25·907	18
19	·7407	22·241	·7593	23·389	·7778	24·574	·7963	25·796	·8148	27·056	19
20	·7593	23·352	·7778	24·519	·7963	25·722	·8148	26·963	·8333	28·241	20
21	·7778	24·500	·7963	25·685	·8148	26·907	·8333	28·167	·8519	29·463	21
22	·7963	25·685	·8148	26·889	·8333	28·130	·8519	29·407	·8704	30·722	22
23	·8148	26·907	·8333	28·130	·8519	29·389	·8704	30·685	·8889	32·019	23
24	·8333	28·167	·8519	29·407	·8704	30·685	·8889	32·000	·9074	33·352	24
25	·8519	29·463	·8704	30·722	·8689	32·019	·9074	33·352	·9259	34·722	25
26	·8704	30·796	·8889	32·074	·9074	33·389	·9259	34·741	·9444	36·130	26
27	·8889	32·167	·9074	33·463	·9259	34·796	·9444	36·167	·9630	37·574	27
28	·9074	33·574	·9259	34·889	·9444	36·241	·9630	37·630	·9815	39·056	28
29	·9259	35·019	·9444	36·352	·9630	37·722	·9815	39·130	1·0000	40·574	29
30	·9444	36·500	·9630	37·852	·9815	39·241	1·0000	40·667	1·0185	42·130	30
31	·9630	38·019	·9815	39·389	1·0000	40·796	1·0185	42·241	1·0370	43·722	31
32	·9815	39·574	1·0000	40·963	1·0185	42·389	1·0370	43·852	1·0556	45·352	32
33	1·0000	41·167	1·0185	42·574	1·0370	44·019	1·0556	45·500	1·0741	47·019	33
34	1·0185	42·796	1·0370	44·222	1·0556	45·685	1·0741	47·185	1·0926	48·722	34
35	1·0370	44·463	1·0556	45·907	1·0741	47·389	1·0926	48·907	1·1111	50·463	35
36	1·0556	46·167	1·0741	47·630	1·0926	49·130	1·1111	50·667	1·1296	52·241	36
37	1·0741	47·907	1·0926	49·389	1·1111	50·907	1·1296	52·463	1·1481	54·056	37
38	1·0926	49·685	1·1111	51·185	1·1296	52·722	1·1481	54·296	1·1667	55·907	38
39	1·1111	51·500	1·1296	53·019	1·1481	54·574	1·1667	56·167	1·1852	57·796	39
40	1·1296	53·352	1·1481	54·889	1·1667	56·463	1·1852	58·074	1·2047	59·722	40

TABLE LXX.—Base 1—Slopes $1\frac{1}{2}$ to 1.

Feet.	26		27		28		29		30		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·4815	12·519	·5000	13·500	·5185	14·519	·5370	15·574	·5556	16·667	0
1	·5000	13·019	·5185	14·019	·5370	15·056	·5556	16·130	·5741	17·241	1
2	·5185	13·556	·5370	14·574	·5556	15·630	·5741	16·722	·5926	17·852	2
3	·5370	14·130	·5556	15·167	·5741	16·241	·5926	17·352	·6111	18·500	3
4	·5556	14·741	·5741	15·796	·5926	16·889	·6111	18·019	·6296	19·185	4
5	·5741	15·389	·5926	16·463	·6111	17·574	·6296	18·722	·6481	19·907	5
6	·5926	16·074	·6111	17·167	·6296	18·296	·6481	19·463	·6667	20·667	6
7	·6111	16·796	·6296	17·907	·6481	19·056	·6667	20·241	·6852	21·463	7
8	·6296	17·556	·6481	18·685	·6667	19·852	·6852	21·056	·7037	22·296	8
9	·6481	18·352	·6667	19·500	·6852	20·685	·7037	21·907	·7222	23·167	9
10	·6667	19·185	·6852	20·352	·7037	21·556	·7222	22·796	·7407	24·074	10
11	·6852	20·056	·7037	21·241	·7222	22·463	·7407	23·722	·7593	25·019	11
12	·7037	20·963	·7222	22·167	·7407	23·407	·7593	24·685	·7778	26·000	12
13	·7222	21·907	·7407	23·130	·7593	24·389	·7778	25·685	·7963	27·019	13
14	·7407	22·889	·7593	24·130	·7778	25·407	·7963	26·722	·8148	28·074	14
15	·7593	23·907	·7778	25·167	·7963	26·463	·8148	27·796	·8333	29·167	15
16	·7778	24·963	·7963	26·241	·8148	27·556	·8333	28·907	·8519	30·296	16
17	·7963	26·056	·8148	27·352	·8333	28·685	·8519	30·056	·8704	31·463	17
18	·8148	27·185	·8333	28·500	·8519	29·852	·8704	31·241	·8889	32·667	18
19	·8333	28·352	·8519	29·685	·8704	31·056	·8889	32·463	·9074	33·907	19
20	·8519	29·556	·8704	30·907	·8889	32·296	·9074	33·722	·9259	35·185	20
21	·8704	30·796	·8889	32·167	·9074	33·574	·9259	35·019	·9444	36·500	21
22	·8889	32·074	·9074	33·463	·9259	34·889	·9444	36·352	·9630	37·852	22
23	·9074	33·389	·9259	34·796	·9444	36·241	·9630	37·722	·9815	39·241	23
24	·9259	34·741	·9444	36·167	·9630	37·630	·9815	39·130	1·0000	40·667	24
25	·9444	36·130	·9630	37·574	·9815	39·056	1·0000	40·574	1·0185	42·130	25
26	·9630	37·556	·9815	39·019	1·0000	40·519	1·0185	42·056	1·0370	43·630	26
27	·9815	39·019	1·0000	40·500	1·0185	42·019	1·0370	43·574	1·0556	45·167	27
28	1·0000	40·519	1·0185	42·019	1·0370	43·556	1·0556	45·130	1·0741	45·741	28
29	1·0185	42·056	1·0370	43·574	1·0556	45·130	1·0741	46·722	1·0926	48·352	29
30	1·0370	43·630	1·0556	45·167	1·0741	46·741	1·0926	48·352	1·1111	50·000	30
31	1·0556	45·241	1·0741	46·796	1·0926	48·389	1·1111	50·019	1·1296	51·685	31
32	1·0741	46·889	1·0926	48·463	1·1111	50·074	1·1296	51·722	1·1481	53·407	32
33	1·0926	48·574	1·1111	50·167	1·1296	51·796	1·1481	53·463	1·1667	55·167	33
34	1·1111	50·296	1·1296	51·907	1·1481	53·556	1·1667	55·241	1·1852	56·963	34
35	1·1296	52·056	1·1481	53·685	1·1667	55·352	1·1852	57·056	1·2047	58·796	35
36	1·1481	53·852	1·1667	55·500	1·1852	57·185	1·2047	58·907	1·2222	60·667	36
37	1·1667	55·685	1·1852	57·352	1·2047	59·056	1·2222	60·796	1·2407	62·574	37
38	1·1852	57·556	1·2047	59·241	1·2222	60·963	1·2407	62·722	1·2593	64·519	38
39	1·2047	59·463	1·2222	61·167	1·2407	62·907	1·2593	64·685	1·2778	66·500	39
40	1·2222	61·407	1·2407	63·130	1·2593	64·889	1·2778	66·685	1·2963	68·519	40

TABLE LXXI.—Base 1.—Slopes 1½ to 1.

Feet.	31		32		33		34		35		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·5741	17·796	·5926	18·963	·6111	20·167	·6296	21·407	·6481	22·685	0
1	·5926	18·389	·6111	19·574	·6296	20·796	·6481	22·056	·6667	23·352	1
2	·6111	19·019	·6296	20·222	·6481	21·463	·6667	22·741	·6852	24·056	2
3	·6296	19·685	·6481	20·907	·6667	22·167	·6852	23·463	·7037	24·796	3
4	·6481	20·389	·6667	21·630	·6852	22·907	·7037	24·222	·7222	25·574	4
5	·6667	21·130	·6852	22·389	·7037	23·685	·7222	25·019	·7407	26·389	5
6	·6852	21·907	·7037	23·185	·7222	24·500	·7407	25·852	·7593	27·241	6
7	·7037	22·722	·7222	24·019	·7407	25·352	·7593	26·722	·7778	28·130	7
8	·7222	23·574	·7407	24·889	·7593	26·241	·7778	27·630	·7963	29·056	8
9	·7407	24·463	·7593	25·796	·7778	27·167	·7963	28·574	·8148	30·019	9
10	·7593	25·389	·7778	26·741	·7963	28·130	·8148	29·556	·8333	31·019	10
11	·7778	26·352	·7963	27·722	·8148	29·130	·8333	30·574	·8519	32·056	11
12	·7963	27·352	·8148	28·741	·8333	30·167	·8519	31·630	·8704	33·130	12
13	·8148	28·389	·8333	29·796	·8519	31·241	·8704	32·722	·8889	34·241	13
14	·8333	29·463	·8519	30·889	·8704	32·352	·8889	33·852	·9074	35·389	14
15	·8519	30·574	·8704	32·019	·8889	33·500	·9074	35·019	·9259	36·574	15
16	·8704	31·722	·8889	33·185	·9074	34·685	·9259	36·222	·9444	37·796	16
17	·8889	32·907	·9074	34·389	·9259	35·907	·9444	37·463	·9630	39·056	17
18	·9074	34·130	·9259	35·630	·9444	37·167	·9630	38·741	·9815	40·352	18
19	·9259	35·389	·9444	36·907	·9630	38·463	·9815	40·056	1·0000	41·685	19
20	·9444	36·685	·9630	38·222	·9815	39·796	1·0000	41·407	1·0185	43·056	20
21	·9630	38·019	·9815	39·574	1·0000	41·167	1·0185	42·796	1·0370	44·463	21
22	·9815	39·389	1·0000	40·963	1·0185	42·574	1·0370	44·222	1·0556	45·907	22
23	1·0000	40·796	1·0185	42·389	1·0370	44·019	1·0556	45·685	1·0741	47·389	23
24	1·0185	42·241	1·0370	43·852	1·0556	45·500	1·0741	47·185	1·0926	48·907	24
25	1·0370	43·722	1·0556	45·352	1·0741	47·019	1·0926	48·722	1·1111	50·463	25
26	1·0556	45·241	1·0741	46·889	1·0926	48·574	1·1111	50·296	1·1296	52·056	26
27	1·0741	46·796	1·0926	48·463	1·1111	50·167	1·1296	51·907	1·1481	53·685	27
28	1·0926	48·389	1·1111	50·074	1·1296	51·796	1·1481	53·556	1·1667	55·352	28
29	1·1111	50·019	1·1296	51·722	1·1481	53·463	1·1667	55·241	1·1852	57·056	29
30	1·1296	51·685	1·1481	53·407	1·1667	55·167	1·1852	56·963	1·2047	58·796	30
31	1·1481	53·389	1·1667	55·130	1·1852	56·907	1·2047	58·722	1·2222	60·574	31
32	1·1667	55·130	1·1852	56·889	1·2047	58·685	1·2222	60·519	1·2407	62·389	32
33	1·1852	56·907	1·2047	58·685	1·2222	60·500	1·2407	62·352	1·2593	64·241	33
34	1·2047	58·722	1·2222	60·519	1·2407	62·352	1·2593	64·222	1·2778	66·130	34
35	1·2222	60·574	1·2407	62·389	1·2593	64·241	1·2778	66·130	1·2963	68·056	35
36	1·2407	62·463	1·2593	64·296	1·2778	66·167	1·2963	68·074	1·3148	70·019	36
37	1·2593	64·389	1·2778	66·241	1·2963	68·130	1·3148	70·056	1·3333	72·019	37
38	1·2778	66·352	1·2963	68·222	1·3148	70·130	1·3333	72·074	1·3519	74·056	38
39	1·2963	68·352	1·3148	70·241	1·3333	72·167	1·3519	74·130	1·3704	76·130	39
40	1·3148	70·389	1·3333	72·296	1·3519	74·241	1·3704	76·222	1·3889	78·241	40

TABLE LXXII.—Base 1.—Slopes $1\frac{1}{2}$ to 1.

Feet.	36		37		38		39		40		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·6667	24·000	·6852	25·352	·7037	26·741	·7222	28·167	·7407	29·630	0
1	·6852	24·685	·7037	26·056	·7222	27·463	·7407	28·907	·7593	30·389	1
2	·7037	25·407	·7222	26·796	·7407	28·222	·7593	29·685	·7778	31·185	2
3	·7222	26·167	·7407	27·574	·7593	29·019	·7778	30·500	·7963	32·019	3
4	·7407	26·963	·7593	28·389	·7778	29·852	·7963	31·352	·8148	32·889	4
5	·7593	27·796	·7778	29·241	·7963	30·722	·8148	32·241	·8333	33·796	5
6	·7778	28·667	·7963	30·130	·8148	31·630	·8333	33·167	·8519	34·741	6
7	·7963	29·574	·8148	31·056	·8333	32·574	·8519	34·130	·8704	35·722	7
8	·8148	30·519	·8333	32·019	·8519	33·556	·8704	35·130	·8889	36·741	8
9	·8333	31·500	·8519	33·019	·8704	34·574	·8889	36·167	·9074	37·796	9
10	·8519	32·529	·8704	34·056	·8889	35·630	·9074	37·241	·9259	38·889	10
11	·8704	33·574	·8889	35·130	·9074	36·722	·9259	38·352	·9444	40·019	11
12	·8889	34·667	·9074	36·241	·9259	37·852	·9444	39 500	·9630	41·185	12
13	·9074	35·796	·9259	37·389	·9444	30·019	·9630	40·685	·9815	42·389	13
14	·9259	36·963	·9444	38·574	·9630	40·222	·9815	41·907	1·0000	43·630	14
15	·9444	38·167	·9630	39·796	·9815	41·463	1·0000	43·167	1·0185	44·907	15
16	·9630	39·407	·9815	41·056	1·0000	42·741	1·0185	44·463	1·0370	46·222	16
17	·9815	40·685	1·0000	42·352	1·0185	44·056	1·0370	45·796	1·0556	47·574	17
18	1·0000	42·000	1·0185	43·685	1·0370	45·407	1·0556	47·167	1·0741	48·963	18
19	1·0185	43·352	1·0370	45·056	1·0556	46·796	1·0741	48·574	1·0926	50·389	19
20	1·0370	44·741	1·0556	46·463	1·0741	48·222	1·0926	50·019	1·1111	51·852	20
21	1·0556	46·167	1·0741	47·907	1·0926	49·685	1·1111	51·500	1·1296	53·352	21
22	1·0741	47·630	1·0926	49·389	1·1111	51·185	1·1296	53·019	1·1481	54·889	22
23	1·0926	49·130	1·1111	50·907	1·1296	52·722	1·1481	54·574	1·1667	56·463	23
24	1·1111	50·667	1·1296	52·463	1·1481	54 296	1·1667	56·167	1·1852	58·074	24
25	1·1296	52·241	1·1481	54·056	1·1667	55 907	1·1852	57·796	1·2047	59·722	25
26	1·1481	53·852	1·1667	55·685	1·1852	57·556	1·2047	59·463	1·2222	61·407	26
27	1·1667	55 500	1·1852	57·352	1·2047	59·241	1·2222	61 167	1·2407	63·130	27
28	1·1852	57·185	1·2047	59·056	1·2222	60·963	1·2407	62·907	1 2593	64·889	28
29	1·2047	58·907	1·2222	60·796	1·2407	62·722	1·2593	64 685	1 2778	66·685	29
30	1·2222	60·667	1·2407	62·574	1·2593	64·519	1·2778	66·500	1·2963	68·519	30
31	1·2407	62·463	1·2593	64·389	1·2778	66·352	1·2963	68 352	1·3148	70·389	31
32	1·2593	64·296	1·2778	66 241	1·2963	68·222	1·3148	70·241	1·3333	72·296	32
33	1·2778	66·167	1·2963	68·130	1·3148	70·130	1·3333	72·167	1·3519	74·241	33
34	1·2963	68·074	1·3148	70·056	1·3333	72·074	1·3519	74·130	1·3704	76·222	34
35	1·3148	70·019	1·3333	72·019	1·3519	74·056	1·3704	76·130	1·3889	78·241	35
36	1·3333	72·000	1·3519	74·019	1·3704	76·074	1·3889	78 167	1·4074	80 296	36
37	1·3519	74·019	1·3704	76·056	1·3889	78·130	1·4074	80·241	1·4259	82 389	37
38	1·3704	76·074	1·3889	78·130	1·4074	80·222	1·4259	82·352	1·4444	84·519	38
39	1·3889	78·167	1·4074	80·241	1·4259	82·352	1·4444	84·500	1·4630	86·685	39
40	1·4074	80 296	1·4259	82·389	1·4444	84·519	1·4630	86·685	1·4815	88 889	40

TABLE LXXIII.—Base 1.—Slopes 2 to 1.

Feet.	1		2		3		4		5		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·0185	·025	·0370	·099	·0556	·222	·0741	·395	·0926	·617	0
1	·0370	·074	·0556	·173	·0741	·321	·0926	·519	·1111	·765	1
2	·0556	·173	·0741	·296	·0926	·469	·1111	·691	·1296	·963	2
3	·0741	·321	·0926	·469	·1111	·667	·1296	·914	·1481	1·210	3
4	·0926	·519	·1111	·691	·1296	·914	·1481	1·185	·1667	1·506	4
5	·1111	·765	·1296	·963	·1481	1·210	·1667	1·506	·1852	1·852	5
6	·1296	1·062	·1481	1·284	·1667	1·556	·1852	1·877	·2037	2·247	6
7	·1481	1·407	·1667	1·654	·1852	1·951	·2037	2·296	·2222	2·691	7
8	·1667	1·802	·1852	2·074	·2037	2·395	·2222	2·765	·2407	3·185	8
9	·1852	2·247	·2037	2·543	·2222	2·889	·2407	3·284	·2593	3·728	9
10	·2037	2·741	·2222	3·062	·2407	3·432	·2593	3·852	·2778	4·321	10
11	·2222	3·284	·2407	3·630	·2593	4·025	·2778	4·469	·2963	4·963	11
12	·2407	3·887	·2593	4·247	·2778	4·667	·2963	5·136	·3148	5·654	12
13	·2593	4·519	·2778	4·914	·2963	5·358	·3148	5·852	·3333	6·395	13
14	·2778	5·210	·2963	5·630	·3148	6·099	·3333	6·617	·3519	7·185	14
15	·2963	5·951	·3148	6·395	·3333	6·889	·3519	7·432	·3704	8·025	15
16	·3148	6·741	·3333	7·210	·3519	7·728	·3704	8·296	·3889	8·914	16
17	·3333	7·580	·3519	8·074	·3704	8·617	·3889	9·210	·4074	9·852	17
18	·3519	8·469	·3704	8·988	·3889	9·556	·4074	10·173	·4259	10·840	18
19	·3704	9·407	·3889	9·951	·4074	10·543	·4259	11·185	·4444	11·877	19
20	·3889	10·395	·4074	10·963	·4259	11·580	·4444	12·247	·4630	12·963	20
21	·4074	11·432	·4259	12·025	·4444	12·667	·4630	13·358	·4815	14·099	21
22	·4259	12·519	·4444	13·136	·4630	13·802	·4815	14·519	·5000	15·284	22
23	·4444	13·654	·4630	14·296	·4815	14·988	·5000	15·728	·5185	16·519	23
24	·4630	14·840	·4815	15·506	·5000	16·222	·5185	16·988	·5370	17·802	24
25	·4815	16·074	·5000	16·765	·5185	17·506	·5370	18·296	·5556	19·136	25
26	·5000	17·358	·5185	18·074	·5370	18·840	·5556	19·654	·5741	20·519	26
27	·5185	18·691	·5370	19·432	·5556	20·222	·5741	21·062	·5926	21·951	27
28	·5370	20·074	·5556	20·840	·5741	21·654	·5926	22·519	·6111	23·432	28
29	·5556	21·506	·5741	22·296	·5926	23·136	·6111	24·025	·6296	24·963	29
30	·5741	22·988	·5926	23·802	·6111	24·667	·6296	25·580	·6481	26·543	30
31	·5926	24·519	·6111	25·358	·6296	26·247	·6481	27·185	·6667	28·173	31
32	·6111	26·099	·6296	26·963	·6481	27·877	·6667	28·840	·6852	29·852	32
33	·6296	27·728	·6481	28·617	·6667	29·556	·6852	30·543	·7037	31·580	33
34	·6481	29·407	·6667	30·321	·6852	31·284	·7037	32·296	·7222	33·358	34
35	·6667	31·136	·6852	32·074	·7037	33·062	·7222	34·099	·7407	35·185	35
36	·6852	32·914	·7037	33·877	·7222	34·889	·7407	35·951	·7593	37·069	36
37	·7037	34·741	·7222	35·728	·7407	36·765	·7593	37·852	·7778	38·98[illegible]	37
38	·7222	36·617	·7407	37·630	·7593	38·691	·7778	39·802	·7963	40·96[illegible]	38
39	·7407	38·543	·7593	39·580	·7778	40·667	·7963	41·802	·8148	42·988	39
40	·7593	40·518	·7778	41·580	·7963	42·691	·8148	43·852	·8333	45·069	40

TABLE LXXIV.—Base 1.—Slopes 2 to 1.

Feet.	6		7		8		9		10		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·1111	·889	·1296	1·210	·1481	1·580	·1667	2·000	·1852	2·469	0
1	·1296	1·062	·1481	1·407	·1667	1·802	·1852	2·247	·2037	2·741	1
2	·1481	1·284	·1667	1·654	·1852	2·074	·2037	2·543	·2222	3·062	2
3	·1667	1·556	·1852	1·951	·2037	2·395	·2222	2·889	·2407	2·432	3
4	·1852	1·877	·2037	2·296	·2222	2·765	·2407	3·284	·2593	3·852	4
5	·2037	2·247	·2222	2·691	·2407	3·185	·2593	3·728	·2778	4·321	5
6	·2222	2·667	·2407	3·136	·2593	3·654	·2778	4·222	·2963	4·840	6
7	·2407	3·136	·2593	3·630	·2778	4·173	·2963	4·765	·3148	5·407	7
8	·2593	3·654	·2778	4·173	·2963	4·741	·3148	5·358	·3333	6·025	8
9	·2778	4·222	·2963	4·765	·3148	5·358	·3333	6·000	·3519	6·691	9
10	·2963	4·840	·3148	5·407	·3333	6·025	·3519	6·691	·3704	7·407	10
11	·3148	5·506	·3333	6·099	·3519	6·741	·3704	7·432	·3889	8·173	11
12	·3333	6·222	·3519	6·840	·3704	7·506	·3889	8·222	·4074	8·988	12
13	·3519	6·988	·3704	7·630	·3889	8·321	·4074	9·062	·4259	9·852	13
14	·3704	7·802	·3889	8·469	·4074	9·185	·4259	9·951	·4444	10·765	14
15	·3889	8·667	·4074	9·358	·4259	10·099	·4444	10·889	·4630	11·728	15
16	·4074	9·580	·4259	10·296	·4444	11·062	·4630	11·877	·4815	12·741	16
17	·4259	10·543	·4444	11·284	·4630	12 074	·4815	12·914	·5000	13·802	17
18	·4444	11·556	·4630	12 321	·4815	13 136	·5000	14·000	·5185	14·914	18
19	·4630	12·617	·4815	13·407	·5000	14 247	·5185	15·136	·5370	16·074	19
20	·4815	13·728	·5000	14·543	·5185	15·407	·5370	16·321	·5556	17·284	20
21	·5000	14 889	·5185	15·728	·5370	16·617	·5556	17·556	·5741	18·543	21
22	·5185	16 099	·5370	16·963	·5556	17 877	·5741	18·840	·5926	19·85[illegible]	22
23	·5370	17 358	·5556	18·247	·5741	19·185	·5926	20·173	·6111	21·210	23
24	·5556	18 667	·5741	19·580	·5926	20 543	·6111	21·556	·6296	22·617	24
25	·5741	20·025	·5926	20·963	·6111	21 951	·6296	22·988	·6481	24·074	25
26	·5926	21·432	·6111	22 395	·6296	23 407	·6481	24·469	·6667	25·580	26
27	·6111	22 889	·6296	23·877	·6481	24 914	·6667	26·000	·685[illegible]	27·136	27
28	·6296	24 395	·6481	25·407	·6667	26 469	·6852	27·580	·7037	28·741	28
29	·6481	25 951	·6667	26 988	·6852	28 074	·7037	29·210	·722[illegible]	30·39[illegible]	29
30	·6667	27·556	685[illegible]	28 617	·7037	29 728	·7222	30·889	·7407	32·09[illegible]	30
31	·6852	29·210	·7037	30·296	7222	31 432	·7407	32·617	·7593	33·85[illegible]	31
32	·7037	30 914	·722[illegible]	32 025	·7407	33 185	·7593	34·395	·7778	35·65[illegible]	32
33	·7222	32 667	·740[illegible]	33·802	·7593	34 988	·7778	36·222	·7963	37·50[illegible]	33
34	·7407	34 469	·759[illegible]	35·630	·7778	36 840	·7963	38·099	·8148	39·40[illegible]	34
35	·759[illegible]	36 321	·777[illegible]	37·506	·7963	38 741	·8148	40·025	·8333	41·35[illegible]	35
36	·7778	38·222	·7963	39·432	·8148	40·691	·8333	42·000	·8519	43·358	36
37	·7963	40·173	8148	41 407	·8333	42 691	·8519	44·025	·8704	45·407	37
38	·8148	42 173	·8333	43·432	8519	44 741	·8704	46 0[illegible]9	·888[illegible]	47·50[illegible]	38
39	·8333	44 222	·8519	45 506	8704	46 840	·8889	43·2[illegible]2	·9074	49·65[illegible]	39
40	·8519	46 321	·8704	47 630	·8889	48 988	·9074	50·395	·9259	51·852	40

TABLE LXXV.—Base 1.—Slopes 2 to 1.

Feet.	11		12		13		14		15		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2037	2·988	·2222	3·556	·2407	4·173	·2593	4·840	·2778	5·556	0
1	·2222	3·284	·2407	3·877	·2593	4·519	·2778	5·210	·2963	5·951	1
2	·2407	3·630	·2593	4·247	·2778	4·914	·2963	5·630	·3148	6·395	2
3	·2593	4·025	·2778	4·667	·2963	5·358	·3148	6·099	·3333	6·889	3
4	·2778	4·469	·2963	5·136	·3148	5·852	·3333	6·617	·3519	7·432	4
5	·2963	4·963	·3148	5·654	·3333	6·395	·3519	7·185	·3704	8·025	5
6	·3148	5·506	·3333	6·222	·3519	6·988	·3704	7·802	·3889	8·667	6
7	·3333	6·099	·3519	6·840	·3704	7·630	·3889	8·469	·4074	9·358	7
8	·3519	6·741	·3704	7·506	·3889	8·321	·4074	9·185	·4259	10·099	8
9	·3704	7·432	·3889	8·222	·4074	9·062	·4259	9·951	·4444	10·889	9
10	·3889	8·173	·4074	8·988	·4259	9·852	·4444	10·765	·4630	11·728	10
11	·4074	8·963	·4259	9·802	·4444	10·691	·4630	11·630	·4815	12·617	11
12	·4259	9·802	·4444	10·667	·4630	11·580	·4815	12·543	·5000	13·556	12
13	·4444	10·691	·4630	11·580	·4815	12·519	·5000	13·509	·5185	14·543	13
14	·4630	11·630	·4815	12·543	·5000	13·506	·5185	14·519	·5370	15·580	14
15	·4815	12·617	·5000	13·556	·5185	14·543	·5370	15·580	·5556	16·667	15
16	·5000	13·654	·5185	14·617	·5370	15·630	·5556	16·69[illegible]	·5741	17·802	16
17	·518[illegible]	14·741	·5370	15·728	·5556	16·765	·5741	17·852	·5926	18·9[illegible]8	17
18	·537[illegible]	15·877	·5556	16·889	·5741	17·951	·5926	19·062	·6111	20·222	18
19	·5556	17·062	·5741	18·099	·5926	19·185	·6111	20·321	·6296	21·506	19
20	·5741	18·296	·5926	19·358	·6111	20·469	·6296	21·630	·6481	22·840	20
21	·5926	19·580	·6111	20·667	·6296	21·802	·6481	22·988	·6667	24·222	21
22	·611[illegible]	20·914	·6296	22·025	·6481	23·185	·6667	24·395	·6852	25·654	22
23	·6296	22·296	·6481	23·432	·6667	24·617	·6852	25·852	·7037	27·136	23
24	·6481	23·728	·6667	24·889	·6852	26·099	·7037	27·358	·7222	28·667	24
25	·6667	25·210	·6852	26·395	·7037	27·630	·7222	28·914	·7407	30·247	25
26	·6852	26·741	·7037	27·951	·7222	29·210	·7407	30·519	·7593	31·877	26
27	·7037	28·321	·7222	29·556	·7407	30·840	·7593	32·173	·7778	33·556	27
28	·7222	29·951	·7407	31·210	·7593	32·519	·7778	33·877	·7963	35·284	28
29	·7407	31·630	·7593	32·914	·7778	34·247	·7963	35·630	·8148	37·062	29
30	·759[illegible]	33·358	·7778	34·667	·7963	36·025	·8148	37·432	·8333	38·889	30
31	·7778	35·136	·7963	36·469	·8148	37·852	·8333	39·284	·8519	40·765	31
32	·7963	36·963	·8148	38·321	·8333	39·728	·8519	41·185	·8704	42·691	32
33	·8148	38·840	·8333	40·222	·8519	41·654	·8704	43·136	·8889	44 667	33
34	8333	40·765	·8519	42·173	·8704	43·630	·8889	45·136	·9074	46·691	34
35	·8519	42·741	·8704	44·173	·8889	45·654	·9074	47·185	·9259	48·765	35
36	·8704	44·765	·8889	46·222	·9074	47·728	·9259	49·284	·9444	50·889	36
37	·8889	46·840	·9074	48·321	·9259	49·852	·9444	51·432	·963[illegible]	53·062	37
38	·9074	48·963	·9259	50·469	·9444	52·025	·9630	53·630	·981[illegible]	55·284	38
39	·9259	51·136	·9414	52·667	·963	54·247	·9815	55·877	1·0000	57·556	39
40	·9444	53·358	·9630	54·914	·9815	56·519	1·0000	58·173	1·0185	59·877	40

TABLE LXXVI.—Base 1.—Slopes 2 to 1.

Feet.	16		17		18		19		20		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·2963	6·321	·3148	7·136	·3333	8·000	·3519	8·914	·3704	9·877	0
1	·3148	6·741	·3333	7·580	·3519	8·469	·3704	9·407	·3889	10·395	1
2	·3333	7·210	·3519	8·074	·3704	8·988	·3889	9·951	·4074	10·963	2
3	·3519	7·728	·3704	8·617	·3889	9·556	·4074	10·543	·4259	11·580	3
4	·3704	8·296	·3889	9·210	·4074	10·173	·4259	11·185	·4444	12·247	4
5	·3889	8·914	·4074	9·852	·4259	10·840	·4444	11·877	·4630	12·963	5
6	·4074	9·580	·4259	10·543	·4444	11·556	·4630	12·617	·4815	13·728	6
7	·4259	10·296	·4444	11·284	·4630	12·321	·4815	13·407	·5000	14·543	8
8	·4444	11·062	·4630	12·074	·4815	13·136	·5000	14·247	·5185	15·407	7
9	·4630	11·877	·4815	12·914	·5000	14·000	·5185	15·136	·5370	16·321	9
10	·4815	12·741	·5000	13·802	·5185	14·914	·5370	16·074	·5556	17·284	10
11	·5000	13·654	·5185	14·741	·5370	15·877	·5556	17·062	·5741	18·296	11
12	·5185	14·617	·5370	15·728	·5556	16·889	·5741	18·099	·5926	19·358	12
13	·5370	15·630	·5556	16·765	·5741	17·951	·5926	19·185	·6111	20·469	18
14	·5556	16·691	·5741	17·852	·5926	19·062	·6111	20·321	·6296	21·630	14
15	·5741	17·802	·5926	18·988	·6111	20·222	·6296	21·506	·6481	22·840	15
16	·5926	18·963	·6111	20·173	·6296	21·432	·6481	22·741	·6667	24·099	16
17	·6111	20·173	·6296	21·407	·6481	22·691	·6667	24·025	·6852	25·407	17
18	·6296	21·432	·6481	22·691	·6667	24·000	·6852	25·358	·7037	26·765	18
19	·6481	22·741	·6667	24·025	·6852	25·358	·7037	26·741	·7222	28·173	19
20	·6667	24·099	·6852	25·407	·7037	26·765	·7222	28·173	·7407	29·630	20
21	·6852	25·506	·7037	26·840	·7222	28·222	·7407	29·654	·7593	31·136	21
22	·7037	26·963	·7222	28·321	·7407	29·728	·7593	31·185	·7778	32 691	22
23	·7222	28·469	·7407	29·852	·7593	31·284	·7778	32·765	·7963	34 296	23
24	·7407	30·025	·7593	31·432	·7778	32·889	·7963	34·395	·814	35·951	24
25	·7593	31·630	·7778	33·062	·7963	34·543	·8148	36·074	·8333	37·654	25
26	·7778	33·284	·7963	34·741	·8148	36·247	·8333	37·802	·8519	39·407	26
27	·7963	34·988	·8148	36·469	·8333	38·000	·8519	39·580	·87 4	41·210	27
28	·8148	36·741	·8333	38·247	·8519	39·802	·8704	41·407	·8889	43·062	28
29	·8333	38·543	·8519	40·074	·8704	41·65	·8889	43·284	·9074	44·963	29
30	·8519	40·395	·8704	41·951	·8889	43·556	·9074	45·210	·9259	46·914	30
31	·8704	42·296	·8889	43·877	·9074	45·506	·9259	47·185	·9444	48·914	31
32	·8889	44·247	·9074	45·852	·9259	47·506	·9444	49·210	·9630	50·963	32
33	·9074	46·247	·9259	47·877	·9444	49·556	·9630	51·284	·9815	53·062	33
34	·9259	48·296	·9444	49·951	·9630	51·654	·9815	53·407	1·0000	55·210	34
35	·9444	50·395	·9630	52·074	·9815	53·802	1·0000	55·580	1·0185	57·407	35
36	·9630	52·543	·9815	54·247	1·0000	56·000	1·0185	57·802	1·0370	59·654	36
37	·9815	54·741	1·0000	56·469	1·0185	58·247	1·0370	60·074	1 0556	61·951	37
38	1·0000	56·988	1·0185	58·741	1·0370	60·543	1·0556	62·395	1·0741	64·296	38
39	1·0185	59·284	1·0370	61·062	1·0555	62·889	1·0741	64·675	1·0926	66·691	39
40	1·0370	61·630	1·0556	63·432	1·0741	65·284	1·0926	67·185	1·1111	69·136	40

TABLE LXXVII.—Base 1.—Slopes 2 to 1.

Feet.	21		22		23		24		25		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·3889	10·889	·4074	11·951	·4259	13·062	·4444	14·222	·4630	15·432	0
1	·4074	11·432	·4259	12·519	·4444	13·654	·4630	14·840	·4815	16·074	1
2	·4259	12·025	·4444	13·136	·4630	14·296	·4815	15·506	·5000	16·765	2
3	·4444	12·667	·4630	13·802	·4815	14·988	·5000	16·222	·5185	17·506	3
4	·4630	13·358	·4815	14·519	·5000	15·728	·5185	16·988	·5370	18·296	4
5	·4815	14·099	·5000	15·284	·5185	16·519	·5370	17·802	·5556	19·136	5
6	·5000	14·889	·5185	16·099	·5370	17·358	·5556	18·667	·5741	20·025	6
7	·5185	15·728	·5370	16·963	·5556	18·247	·5741	19·580	·5926	20·963	7
8	·5370	16·617	·5556	17·877	·5741	19·185	·5926	20·543	·6111	21·951	8
9	·5556	17·556	·5741	18·840	·5926	20·173	·6111	21·556	·6296	22·988	9
10	·5741	18 543	·5926	19·852	·6111	21·210	·6296	22·617	·6481	24·074	10
11	·5926	19·580	·6111	20·914	·6296	22·296	·6481	23·728	·6667	25·210	11
12	·6111	20·667	·6296	22·025	·6481	23·432	·6667	24·889	·6852	26·395	12
13	·6296	21·802	·6481	23·185	·6667	24·617	·6852	26·099	·7037	27·630	13
14	·6481	22·988	·6667	24·395	·6852	25·852	·7037	27·358	·7222	28·914	14
15	·6667	24·222	·6852	25·654	·7037	27·136	·7222	28·667	·7407	30·247	15
16	·6852	25·506	·7037	26·963	·7222	28·469	·7407	30·025	·7593	31·630	16
17	·7037	26·840	·7222	28·321	·7407	29·852	·7593	31·432	·7778	33·062	17
18	·7222	28·222	·7407	29·728	·7593	31·284	·7778	32·889	·7963	34·543	18
19	·7407	29·654	·7593	31·185	·7778	32·765	·7963	34·395	·8148	36·074	19
20	·7593	31·136	·7778	32·691	·7963	34·296	·8148	35·951	·8333	37·654	20
21	·7778	32·667	·7963	34·247	·8148	35·877	·8333	37·556	·8519	39·284	21
22	·7963	34 247	·8148	35·852	·8333	37·506	·8519	39·210	·8704	40·963	22
23	·8148	35·877	·8333	37·506	·8519	39·185	·8704	40·914	·8889	42·691	23
24	·8333	37·556	·8519	39·210	·8704	40·914	·8889	42·667	·9074	44·469	24
25	·8519	39·284	·8704	40·963	·8889	42·691	·9074	44·469	·9259	46·296	25
26	·8704	41·062	·8889	42·765	·9074	44·519	·9259	46·321	·9444	48·173	26
27	·8889	42·889	·9074	44·617	·9259	46·395	·9444	48·222	·9630	50·099	27
28	·9074	44·765	·9259	46·519	·9444	48·321	·9630	50·173	·9815	52·074	28
29	·9259	46·691	·9444	48·469	·9630	50·296	·9815	52·173	1·0000	54·099	29
30	·9444	48·667	·9630	50·469	·9815	52·321	1·0000	54·222	1·0185	56·173	30
31	·9630	50·691	·9815	52·519	1·0000	54·395	1·0185	56·321	1·0370	58·296	31
32	·9815	52·765	1·0000	54·617	1·0185	56·519	1·0370	58·469	1 0556	60·469	32
33	1·0000	54·889	1·0185	56·765	1·0370	58·691	1·0556	60·667	1·0741	62·691	33
34	1·0185	57·062	1·0370	58·963	1·0556	60·914	1·0741	62·914	1·0926	64·963	34
35	1·0370	59·284	1·0556	61·210	1·0741	63·185	1·0926	65·210	1·1111	67·284	35
36	1·0556	61·556	1·0741	63·506	1 0926	65·506	1·1111	67·556	1·1296	69·654	36
37	1·0741	63·877	1·0926	65·852	1·1111	67·877	1·1296	69·951	1·1481	72·074	37
38	1·0926	66·247	1·1111	68·247	1·1296	70·296	1·1481	72·395	1·1667	74·543	38
39	1·1111	68·667	1·1296	70·691	1·1481	72·765	1·1667	74·889	1·1852	77·062	39
40	1·1296	71·136	1·1481	73·185	1·1667	75·284	1·1852	77·432	1·2047	79·630	40

TABLE LXXVIII.—Base 1.—Slopes 2 to 1.

Feet.	26		27		28		29		30		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·4815	16·691	·5000	18·000	·5185	19·358	·5370	20·765	·5556	22 222	0
1	·5000	17·358	·5185	18·691	·5370	20·074	·5556	21·506	·5741	22·988	1
2	·5185	18·075	·5370	19·432	·5556	20·840	·5741	22·296	·5926	23·802	2
3	·5370	18·840	·5556	20·222	·5741	21·654	5926	23·136	·6111	24·667	3
4	·5556	19·654	·5741	21·062	·5926	22·519	·6111	24·025	·6296	25·580	4
5	·5741	20·519	·5926	21·951	·6111	23·432	·6296	24·963	·6481	26·543	5
6	·5926	21·432	·6111	22·889	·6296	24·395	·6481	25·951	·6667	27·556	6
7	·6111	22·395	·6296	23·877	·6481	25·407	·6667	26·988	·6852	28·617	7
8	·6296	23·407	·6481	24·914	·6667	26·469	·6852	28·074	·7037	29·728	8
9	·6481	24·469	·6667	26·000	·6852	27·580	·7037	29·210	·7222	30·889	9
10	·6667	25·580	·6852	27·136	·7037	28·741	·7222	30·395	·7407	32·099	10
11	·6852	26·741	·7037	28·321	·7222	29·951	·7407	31·630	·7593	33·358	11
12	·7037	27·951	·7222	29·556	·7407	31·21	·7593	32·914	·7778	34·667	12
13	·7222	29·210	·7407	30·840	·7593	32·519	·7778	34·247	·7963	36·025	13
14	·7407	30·519	·7593	32·173	·7778	33·877	·7963	35·630	·8148	37·432	14
15	·7593	31·877	·7778	33·556	·7963	35·284	·8148	37·062	·8333	38·889	15
16	·7778	33·284	·7963	34·988	·8148	36·741	·8333	38·543	·8519	40·395	16
17	·7963	34·741	·8148	36·469	·8333	38·247	·8519	40·074	·8704	41·951	17
18	·8148	36·247	·8333	38·000	·8519	39·802	·8704	41·654	·8889	43·556	18
19	·8333	37·802	·8519	39·580	·8704	41·407	·8889	43·284	·9074	45·210	19
20	·8519	39·407	·8704	41·210	·8889	43·062	·9074	44·963	·9259	46·914	20
21	·8704	41·062	·8889	42·889	·9074	45·765	·9259	46·691	·9444	48·667	21
22	·8889	42·765	·9074	44·617	·9259	46·519	·9444	48·469	·9630	50·469	22
23	·9074	44·519	·9259	46·395	·9444	48·321	·9630	50·296	·9815	52·321	23
24	·9259	46·321	·9444	48·222	·9630	50·173	·9815	52·173	1·0000	54·222	24
25	·9444	48·173	·9630	50·099	·9815	52·074	1·0000	54·099	1·0185	56·173	25
26	·9630	50·074	·9815	52·025	1·0000	54·025	1·0185	56·074	1·0370	58·173	26
27	·9815	52·025	1·0000	54·000	1·0185	56·025	1·0370	58·099	1·0556	60·222	27
28	1·0000	54·025	1·0185	56·025	1·0370	58·074	1·0556	60·173	1·0741	62·321	28
29	1·0185	56·074	1·0370	58·099	1·0556	60·173	1·0741	62·296	1·0926	64·469	29
30	1·0370	58·173	1·0556	60·222	1·0741	62·321	1·0926	64·469	1·1111	66·667	30
31	1·0556	60·321	1·0741	62·395	1·0926	64·519	1·1111	66·691	1·1296	68·914	31
32	1·0741	62·519	1·0926	64·617	1·1111	66·765	1·1296	68·963	1·1481	71·210	32
33	1·0926	64·765	1·1111	66·889	1·1296	69·062	1·1481	71·284	1·1667	73·556	23
34	1·1111	67·062	1·1296	69·210	1·1481	71·407	1·1667	73·654	1·1852	75·951	34
35	1·1296	69·407	1·1481	71·580	1·1667	73·802	1·1852	76·074	1·2047	78·395	35
36	1·1481	71·802	1·1667	74·009	1·1852	76 247	1·2047	78·543	1·2222	80·889	36
37	1·1667	74·247	1·1852	76·469	1·2047	78·741	1·2222	81·062	1·2407	83·432	37
38	1·1852	76·741	1·2047	78·988	1·2222	81·284	1·2407	83·630	1·2593	86·025	38
39	1·2047	79·284	1·2222	81·556	1·2407	83·877	1·2593	86·247	1·2778	88·667	39
40	1·2222	81·877	1·2407	84·173	1·2593	86·519	1·2778	88·914	1·2963	91·358	40

TABLE LXXIX.—Base 1.—Slopes 2 to 1.

Feet.	31		32		33		34		35		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·5741	23·728	·5926	25·284	·6111	26·889	·6296	28·543	·6481	30·247	0
1	·5926	24·519	·6111	26·099	·6296	27·728	·6481	29·407	·6667	31·136	1
2	·6111	25·358	·6296	26·963	·6481	28·617	·6667	30·321	·6852	32·074	2
3	·6296	26·247	·6481	27·877	·6667	29·556	·6852	31·284	·7037	33·062	3
4	·6481	27·185	·6667	28·840	·6852	30·543	·7037	32·296	·7222	34·099	4
5	·6667	28·273	6852	29·852	·7037	31·580	·7222	33·358	·7407	35·185	5
6	·6852	29·210	·7037	30·914	·7222	32·667	·7407	34·469	·7593	36·321	6
7	·7037	30·296	·7222	32·025	·7407	33·802	·7593	35·630	·7778	37·506	7
8	·7222	31·432	·7407	33·185	·7593	34·988	·7778	36·840	·7963	38·741	8
9	·7407	32·617	·7593	34·395	·7778	36·222	·7963	38·099	·8148	40·025	9
10	·7593	33·852	·7778	35·654	·7963	37·506	·8148	39·407	·8333	41·358	10
11	·7778	35·136	·7963	36·963	·8148	38·840	·8333	40·765	·8519	42·741	11
12	·7963	36·469	·8148	38·321	·8333	40·222	·8519	42·173	·8704	44·173	12
13	·8148	37·852	·8333	39·728	·8519	41·654	·8704	43·630	·8889	45·654	13
14	·8333	39·284	·8519	41·185	·8704	43·136	·8889	45·136	·9074	47·185	14
15	·8519	40·765	·8704	42·691	·8889	44·667	·9074	46·691	·9259	48·765	15
16	·8704	42·296	·8889	44·247	·9074	46·247	·9259	48·296	·9444	50·395	16
17	·8889	43·877	·9074	45·852	·9259	47·877	·9444	49 951	·9630	52·074	17
18	·9074	45·506	·9259	47·506	·9444	49·556	·9630	51·654	·9815	53·802	18
19	·9259	47·185	·9444	49·210	·9630	51·284	·9815	53·407	1·0000	55·580	19
20	·9444	48·914	·9630	50·963	·9815	53·062	1·0000	55·210	1·0185	57·407	20
21	·9630	50·691	·9815	52·765	1·0000	54·889	1·0185	57·062	1·0370	59·284	21
22	·9815	52·519	1·0000	54·617	1·0185	56·765	1·0370	58·963	1·0556	61·210	22
23	1·0000	54·395	1·0185	56·519	1·0370	58·691	1·0556	60·914	1·0741	63·185	23
24	1·0185	56·321	1·0370	58·469	1·0556	60·667	1·0741	62·914	1·0926	65·210	24
25	1·0370	58·296	1·0556	60·469	1·0741	62·691	1·0926	64·963	1·1111	67·284	25
26	1·0556	60·321	1·0741	62·519	1·0926	64·765	1·1111	67·062	1·1296	69·407	26
27	1·0741	62·395	1·0926	64·617	1·1111	66·889	1·1296	69·210	1·1481	71·580	27
28	1·0926	64·519	1·1111	66·765	1·1296	69·062	1·1481	71·407	1·1667	73·802	28
29	1·1111	66·691	1·1296	68·963	1·1481	71·284	1·1667	73·654	1·1852	76·074	29
30	1·1296	68·914	1·1481	71·210	1·1667	73·556	1·1852	75·951	1·2047	78·395	30
31	1·1481	71·185	1·1667	73·506	1·1852	75·877	1·2047	78·296	1·2222	80·765	31
32	1·1667	73·506	1·1852	75·852	1·2047	78·247	1·2222	80·691	1·2407	83·185	32
33	1·1852	75·877	1·2047	78·247	1·2222	80·667	1·2407	83·136	1·2593	85·654	33
34	1·2047	78·296	1·2222	80·691	1·2407	83·136	1·2593	85·630	1·2778	88·173	34
35	1·2222	80·765	1·2407	83·185	1·2593	85·654	1·2778	88·173	1·2963	90·741	35
36	1·2407	83·284	1·2593	85·728	1·2778	88·222	1·2963	90·765	1·3148	93·358	36
37	1·2593	85·852	1·2778	88·321	1·2963	90·840	1·3148	93·407	1·3333	96·025	37
38	1·2778	88·469	1·2963	90·963	1·3148	93·506	1·3333	96·099	1·3519	98·741	38
39	1·2963	91·136	1·3148	93·654	1·3333	96·222	1·3519	98·840	1·3704	101·506	39
40	1·3148	93·852	1·3333	96·395	1·3519	98·988	1·3704	101·630	1·3089	104·321	40

TABLE LXXX.—Base 1.—Slopes 2 to 1.

Feet.	36		37		38		39		40		Feet.
	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	Mult.	Add.	
0	·6667	32·000	·6852	33·802	·7037	35·654	·7222	37·556	·7407	39·506	0
1	·6852	32·914	·7037	34·741	·7222	36·617	·7407	38·543	·7593	40·519	1
2	·7037	33·877	·7222	35·728	·7407	37·630	·7593	39·580	·7778	41·580	2
3	·7222	34·889	·7407	36·765	·7593	38·691	·7778	40·667	·7963	42·691	3
4	·7407	35·951	·7593	37·852	·7778	39·802	·7963	41·802	·8148	43·852	4
5	·7593	37·062	·7778	38·988	·7963	40·963	·8148	42·988	·8333	45·062	5
6	·7778	38·222	·7963	40·173	·8148	42·173	·8333	44·222	·8519	46·321	6
7	·7963	39·432	·8148	41·407	·8333	43·432	·8519	45·506	·8704	47·630	7
8	·8148	40·691	·8333	42·691	·8519	44·741	·8704	46·840	·8889	48·988	8
9	·8333	42·000	·8519	44·025	·8704	46·099	·8889	48·222	·9074	50·395	9
10	·8519	43·358	·8704	45·407	·8889	47·506	·9074	49·654	·9259	51·852	10
11	·8704	44·765	·8889	46·840	·9074	48·963	·9259	51·136	·9444	53·358	11
12	·8889	46·222	·9074	48·321	·9259	50·469	·9444	52·667	·9630	54·914	12
13	·9074	47·728	·9259	49·852	·9444	52·025	·9630	54·247	·9815	56·519	13
14	·9259	49·284	·9444	51·432	·9630	53·630	·9815	55·877	1·0000	58·173	14
15	·9444	50·889	·9630	53·062	·9815	55·284	1·0000	57·556	1·0185	59·877	15
16	·9630	52·543	·9815	54·741	1·0000	56·988	1·0185	59·284	1·0370	61·630	16
17	·9815	54·247	1·0000	56·469	1·0185	58·741	1·0370	61·062	1·0556	63·432	17
18	1·0000	56·000	1·0185	58·247	1·0370	60·543	1·0556	62·889	1·0741	65·284	18
19	1·0185	57·802	1·0370	60·074	1·0556	62·395	1·0741	64·765	1·0926	67·185	19
20	1·0370	59·654	1·0556	61·951	1·0741	64·296	1·0926	66·691	1·1111	69·136	20
21	1·0556	61·556	1·0741	63·877	1·0926	66·247	1·1111	68·667	1·1296	71·136	21
22	1·0741	63·506	1·0926	65·852	1·1111	68·247	1·1296	70·691	1·1481	73·185	22
23	1·0926	65·506	1·1111	67·877	1·1296	70·296	1·1481	72·765	1·1667	75·284	23
24	1·1111	67·556	1·1296	69·951	1·1481	72·395	1·1667	74·889	1·1852	77·432	24
25	1·1296	69·654	1·1481	72·074	1·1667	74·543	1·1852	77·062	1·2047	79·630	25
26	1·1481	71·802	1·1667	74·247	1·1852	76·741	1·2047	79·284	1·2222	81·877	26
27	1·1667	74·000	1·1852	76·469	1·2047	78·988	1·2222	81·556	1·2407	84·173	27
28	1·1852	76·247	1·2047	78·741	1·2222	81·284	1·2407	83·877	1·2593	86·519	28
29	1·2047	78·543	1 2222	81·062	1·2407	83·630	1·2593	86·247	1·2778	88·914	29
30	1·2222	80·889	1·2407	83·432	1·2593	86·025	1·2778	88·667	1·2963	91·358	30
31	1·2407	83·284	1·2593	85·852	1·2778	88·469	1·2963	91·136	1·3148	93·852	31
32	1·2593	85·728	1·2778	88·321	1·2963	90·963	1·3148	93·654	1·3333	96·395	32
33	1·2778	88·222	1·2963	90·840	1·3148	93·506	1·3333	96·222	1·3519	98·988	33
34	1·2963	90·765	1·3148	93·407	1·3333	96·099	1·3519	98·840	1·3704	101·630	34
35	1·3148	93·358	1·3333	96·025	1·3519	98·741	1·3704	101·506	1·3889	104·321	35
36	1·3333	96·000	1·3519	98·691	1·3704	101·432	1·3889	104·222	1·4074	107·062	36
37	1·3519	98·691	1·3704	101·407	1·3889	104·173	1·4074	106·988	1·4259	109·852	37
38	1·3704	101·432	1·3889	104·173	1·4074	106·963	1·4259	109·802	1·4444	112·691	38
39	1·3889	104·222	1·4074	106·988	1·4259	109·802	1·4444	112·667	1·4630	115·580	39
40	1·4074	107·062	1·4259	109·852	1·4444	112·691	1·4630	115·580	1·4815	118·519	40

TABLE LXXXI.

For calculating the Area of the Arch Ring and Segment of Intrados of any Arch of the undermentioned rise and thickness.

Thickness of Arch Ring.	RISE = ⅓ SPAN.			RISE = ¼ SPAN.			RISE = ⅕ SPAN.			RISE = ⅙ SPAN.			RISE = ⅐ SPAN.			Thickness of Arch Ring.
	Area of Segment.	Area of Arch Ring.		Area of Segment.	Area of Arch Ring.		Area of Segment.	Area of Arch Ring.		Area of Segment.	Area of Arch Ring.		Area of Segment.	Area of Arch Ring.		
		Multiply.	Add.		Multiply.	Add.		Multiply.	Add.		Multiply.	Add.		Multiply.	Add.	
6″		·6370	·2940		·5795	·2318		·5517	·1902		·5362	·1608		·5267	·1391	6″
9″		·9555	·6615		·8693	·5216		·8276	·4280		·8043	·3619		·7901	·3131	9″
12″		1·2740	1·1760		1·1591	·9273		1·1034	·7610		1·0725	·6435		1·0535	·5566	12″
15″		1·5925	1·8375		1·4489	1·4489		1·3793	1·1890		1·3406	1·0054		1·3169	·8697	15″
18″		1·9110	2·6460		1·7387	2·0864		1·6552	1·7122		1·6087	1·4478		1·5803	1·2523	18″
21″	·240878 × (Span)²	2·2295	3·6015	·174724 × (Span)²	2·0285	2·8398	·137505 × (Span)²	1·9310	2·3306	·113543 × (Span)²	1·8769	1·9707	·096778 × (Span)²	1·8437	1·7046	21″
24″		2·5480	4·7040		2·3182	3·7092		2·2069	3·0440		2·1450	2·5740		2·1071	2·2264	24″
27″		2·8665	5·9535		2·6080	4·6944		2·4828	3·8526		2·4131	3·2577		2·3705	2·8178	27″
30″		3·1850	7·3500		2·8978	5·7956		2·7586	4·7563		2·6812	4·0219		2·6339	3·4787	30″
33″		3·5035	8·8936		3·1876	7·0127		3·0345	5·7551		2·9493	4·8665		2·8973	4·2093	33″
36″		3·8220	10·5840		3·4773	8·3456		3·3104	6·8491		3·2175	5·7915		3·1605	5·0094	36″
	Radius = ·541$\dot{6}$ × Span.			Radius = ·625 × Span.			Radius = ·725 × Span.			Radius = ·8$\dot{3}$ × Span.			Radius = ·946428 × Span.			

EXAMPLE.

Given Span.....30 feet
,, Rise ..... ⅓ Span
Thickness of Arch Ring 18″

Then Area of Arch Ring = (1·6552 × 30) + 1·7122 = 51·36 Square feet.
,, ,, Segment of Intrados = ·137505 × 30^2 = 123·75 ,,
,, Radius of Circle ..... = ·725 × 30 = 21·75 feet.

TABLE LXXXII.

Areas of Arch Rings, Segments, &c.

Span.	Area of Segment.	Rise = ½ Span. Thickness of Ring.							Area of Segment.	Rise = ⅓ Span. Thickness of Ring.						
		9″	12″	15″	18″	21″	24″	27″		9″	12″	15″	18″	21″	24″	27″
V	9·81	6·77	9·42	12·2	15·3	...	...	...	6·02	5·43	7·54	9·80	12·2	...	...	...
VI	14·1	7·95	10·9	14·2	17·6	..	...	...	8·67	6·39	8·82	11·3	14·1	...	...	...
VII	19·2	9·13	12·5	16·2	20·0	...	...	...	11·8	7·35	10·0	12·9	16·0	...	...	...
VIII	25·1	10·3	14·1	18·1	22·3	...	...	..	15·4	8·30	11·3	14·5	17·9	...	...	...
IX	31·8	11·4	15·7	20·1	24·7	...	...	...	19·5	9·26	12·6	16·1	19·8	...	...	...
X	39·2	12·6	17·2	22·0	27·0	32·2	...	...	24·0	10·2	13·9	17·7	21·7	25·8	...	...
XII	56·5	15·0	20·4	26·0	31·8	37·8	...	...	34·6	12·1	16·4	20·9	25·5	30·3	...	...
XV	88·3	18·5	25·1	31·9	38·8	46·0	...	...	54·1	14·9	20·2	25·7	31·3	37·0	...	...
XVIII	127	...	29·8	37·8	45·9	54·2	62·8	...	78·0	...	24·2	30·5	37·0	43·7	50·5	...
XX	157	...	32·9	41·7	50·6	59·7	69·1	...	96·3	...	26·6	33·6	40·8	48·1	55·6	...
XXV	245	...	40·8	51·5	62·4	73·5	84·8	...	150	...	33·0	41·6	50·4	59·3	68·4	...
XXX	353	...	...	61·3	74·2	87·2	100	113	216	...	...	49·6	59·9	70·4	81·1	91·9
XXXV	481	...	...	71·1	86·0	101	116	131	295	...	...	57·5	69·5	81·6	93·8	106
XL	628	...	...	80·9	97·7	114	131	149	385	...	...	65·5	79·0	92·7	106	120
XLV	795	...	...	90·8	109	128	147	166	487	...	...	73·5	88·6	103	119	134
	Radius of Circle = ·5 Span.									Radius of Circle = ·541 Span.						

Note.—All areas are given in square feet.

TABLE LXXXIII,

Areas of Arch Rings, Segments, &c.

Span.	Area of Segment.	Rise = ¼ Span. Thickness of Ring.							Area of Segment.	Rise = ⅖ Span. Thickness of Ring.						
		9″	12″	15″	18″	21″	24″	27″		9″	12″	15″	18″	21″	24″	27″
V	4·36	4·86	6·72	8·69	10·7	...	...	...	3·43	4·56	6·27	8·08	9·98	...	...	...
VI	6·29	5·73	7·88	10·1	12·5	...	...	...	4·95	5·39	7·38	9·46	11·6	...	...	...
VII	8·56	6·60	9·04	11·5	14·2	...	...	...	6·73	6·22	8·48	10·8	13·2	...	...	...
VIII	11·1	7·47	10·2	13·0	15·9	...	...	...	8·80	7·04	9·58	12·2	14·9	...	...	...
IX	14·1	8·34	11·3	14·4	17·7	...	...	...	11·1	7·87	10·6	13·6	16·6	...	...	...
X	17·4	9·21	12·5	15·9	19·4	23·1	...	...	13·7	8·70	11·7	14·9	18·2	21·6	...	...
XII	25·1	10·9	14·8	18·8	22·9	27·1	...	...	19·8	10·3	14·0	17·7	21·5	25·5	...	...
XV	39·3	13·5	18·3	23·1	28·1	33·2	...	...	30·9	12·8	17·3	21·8	26·5	31·2	...	...
XVIII	56·6	...	21·7	27·5	33·3	39·3	45·4	...	44·5	...	20·6	26·0	31·5	37·0	42·7	...
XX	69·8	...	24·1	30·4	36·8	43·4	50·0	...	55·0	...	22·8	28·7	34·8	40·9	47·1	...
XXV	109	...	29·9	37·6	45·5	53·5	61·6	...	85·9	...	28·3	35·6	43·0	50·6	58·2	...
XXX	157	...	...	44·9	54·2	63·6	73·2	82·9	123	...	...	42·5	51·3	60·2	69·2	78·3
XXXV	214	...	...	52·1	62·9	73·8	84·8	95·9	168	...	...	49·4	59·6	69·9	80·2	90·7
XL	279	...	...	59·4	71·6	83·9	96·4	109	220	...	...	56·3	67·9	79·5	91·3	103
XLV	353	...	...	66·6	80·3	94·1	108	122	278	...	...	63·2	76·1	89·2	102	115
		Radius of Circle = ·625 Span.								Radius of Circle = ·725 Span.						

Note.—All areas are given in square feet.

TABLE LXXXIV.

Areas of Arch Rings, Segments, &c.

Span.	Area of Segment.	Rise = ⅛ Span. Thickness of Ring.							Area of Segment.	Rise = ¼ Span. Thickness of Ring.						
		9″	12″	15″	18″	21″	24″	27″		9″	12″	15″	18″	21″	24″	27″
V	2·83	4·38	6·00	7·70	9·49	...	...	...	2·41	4·26	5·82	7·45	9·15	...	...	...
VI	4·08	5·18	7·07	9·04	11·1	...	...	...	3·48	5·05	6·87	8·77	10·7	...	...	...
VII	5·56	5·99	8·15	10·3	12·7	...	...	...	4·74	5·84	7·93	10·0	12·3	...	...	..
VIII	7·26	6·79	9·22	11·7	14·3	...	...	...	6·19	6·63	8·98	11·4	13·8	...	...	...
IX	9·19	7·60	10·2	13·0	15·9	...	...	...	7·83	7·42	10·0	12·7	15·4	...	...	...
X	11·3	8·40	11·3	14·4	17·5	20·7	...	...	9·67	8·21	11·0	14·0	17·0	20·1	...	...
XII	16·3	10·0	13·5	17·0	20·7	24·4	...	...	13·9	9·79	13·1	16·6	20·2	23·8	...	...
XV	25·5	12·4	16·7	21·1	25·5	30·1	...	...	21·7	12·1	16·3	20·6	24·9	29·3	...	...
XVIII	36·7	...	19·9	25·1	30·4	35·7	41·1	...	31·3	...	19·5	24·5	29·6	34·8	40·1	...
XX	45·4	...	22·0	27·8	33·6	39·5	45·4	...	38·7	...	21·6	27·2	32·8	38·5	44·3	...
XXV	70·9	...	27·4	34·5	41·6	48·8	56·1	...	60·4	...	26·8	33·7	40·7	47·7	54·9	...
XXX	102	...	...	41·2	49·7	58·2	66·9	75·6	87·1	...	...	40·3	48·6	57·0	65·4	73·9
XXXV	139	...	...	47·9	57·7	67·6	77·6	87·7	118	...	...	46·9	56·5	66·2	75·9	85·7
XL	181	...	...	54·6	65·7	77·0	88·3	99·7	154	...	...	53·5	64·4	75·4	86·5	97·6
XLV	229	...	...	61·3	73·8	86·4	99·0	111	195	...	...	60·1	72·3	84·6	97·0	109
		Radius of Circle = ·83 Span.								Radius of Circle = ·946 Span.						

Note.—All areas are given in square feet.

XIII.—APPENDIX.

USEFUL MEMORANDA AND TABLES.

IRRIGATION.

Water.—One cubic inch weighs 252·2 grains = ·577 oz. = ·0361 lbs., and contains ·577 fluid oz.

One cubic foot weighs, approximately, 1,000 oz. avoirdupois = 62·4 lbs. = ·577 cwt. = ·028 tons, and contains 6·235 gallons.

One cubic yard weighs 14·905 cwt. = ·75034 tons, contains 27 cubic feet = 168·3 gallons.

One cubic Mitre weighs 2198·08 cwt. = approximately one ton.

One ton equals 224 gallons = 35·98 cubic feet = 3·3 feet cube.

One fluid oz. weighs 437·5 grains avoirdupois, and contains 1·735 cubic inches.

One pint weighs 8750 grains = approximately 1·25 lbs., and contains ·02 cubic foot = 34·56 cubic inches.

One gallon Imperial at 62° F. weighs 70,000 grains, approximately 10 lbs., and contains 8 pints = ·1604 cubic foot.

One foot head = ·4335 lb. pressure per square inch.

One pound pressure per square inch = 27·71 inches, head = 2·3093 feet, head.

One cubic foot ice weighs 57·2 lbs.: specific gravity = ·9175.

Water expands $\frac{1}{11\frac{1}{2}}$ in becoming ice.

Water compresses $\frac{1}{100}$ of an inch for each atmosphere (15 lbs. per square inch).

Water boils at 212° F. at sea level, and at 1° less for every 520 feet of elevation.

Sea water weighs $1\frac{3}{4}$ lbs. per cubic foot more than fresh water.

One cubic foot per second equals 538,272 gallons per day = 2400 tons per day.

Water Power.—8·814 cubic feet, falling 1 foot per second = 528·846 cubic feet: falling 1 foot per minute equals 33,000 feet pounds per minute = one horse-power (theoretical).

Rule.—$62{\cdot}4 \times \frac{\text{cubic feet falling per second} \times \text{height in feet}}{550} =$ Horse-power.

Government of India assumes 15 cubic feet falling 1 foot per second to be a horse-power in practice, thus making the co-efficient ·521 (nearly).

Rainfall.—One inch per hour per acre equals nearly 1 cubic foot per second : per acre = 22,622 gallons or 101 tons, per acre per hour.

One inch per hour on a square mile equals 645·32 cubic feet per second per square mile.

One inch per annum per acre will give a supply equal to a run off of ·0,001,151 cubic foot per second, or ·007 cubic foot per minute, or ·4 cubic foot per hour, or 10 cubic feet per day during the year.

One inch per square mile equals 40,000 gallons=6,414·9 cubic feet per day.

Gauging.—The number of cubic inches of rain water (or ounces of water $\times \frac{1}{1 \cdot 733}$) gauged, divided by area of funnel of gauge in inches equals depths of rainfall in inches.

Useful Numbers :—

Square feet in one acre	=43560.
Do. in one square mile	=27,878,400.
Acres in one square mile	=640.
Square miles in one acre	=·0015625.
Acres in a mile of canal	=·1212 × average breadth inside fences.

Running feet per second × ·68 = miles per hour.

CONVERSION TABLE.

Rates per Minute, Hour, Day, Year. Equivalent to rates per Second.

S.	Min.	Hour.	Day (24 H.)	Year.	S.
1	60	3600	86400	31536000	1
2	120	7200	172800	63072000	2
3	180	10800	259200	94608000	3
4	240	14400	345600	126144000	4
5	300	18000	432000	157680000	5
6	360	21600	518400	189216000	6
7	420	25200	604800	220752000	7
8	480	28800	691200	252288000	8
9	540	32400	777600	283824000	9
10	600	36000	864000	315360000	10

Rates per Second, Hour, Day, Year. Equivalent to rates per Minute.

M.	Second.	Hour.	Day (24 H.)	Year.	M.
1	·016667	60	1440	525600	1
2	·033334	120	2880	1051200	2
3	·050000	180	4320	1576800	
4	·066667	240	5760	2102400	4
5	·083334	300	7200	2628000	5
6	·100000	360	8640	3153600	6
7	·116667	420	10080	3679200	7
8	·133334	480	11520	4204800	8
9	·150000	540	12960	4730400	9
10	·166666	600	14400	5256000	10

Example :—If 3 C. F. are discharged by a pipe per second, what is the discharge per day. By 1st Table in 4th column = 259,200 cubic feet.

Rates per Second, Minute, Day, Year. Equivalent to Rate per Hour.

H.	Second.	Minute.	Day (24 H)	Year.	H.
1	·0027778	·0166667	24	8760	1
2	·0055556	·0333334	48	17520	2
3	·0083334	·0500001	72	26280	3
4	·0111112	·0666668	96	35040	4
5	·0138890	·0833335	120	43800	5
6	·0166668	·1000002	144	52560	6
7	·0194446	·1166669	168	61320	7
8	·0222224	·1333336	192	70080	8
9	·0250002	·1500003	216	78840	9
10	·0277778	·1666667	240	87600	10

Rates per Second, Minute, Hour, Year. Equivalent to Rate per Day.

D. (24 H)	Second.	Minute.	Hour.	Year.	D. (24 H)
1	·000011574	·0006944	·041666	365	1
2	·000023148	·0013888	·083333	730	2
3	·00003472	·0020832	·125000	1095	3
4	·00004629	·0027776	·166666	1460	4
5	·00005787	·0034720	·208334	1825	5
6	·00006944	·0041664	·250000	2190	6
7	·00008101	·0048608	·291666	2555	7
8	·00009259	·0055552	·333333	2920	8
9	·00010416	·0062496	·375000	3285	9
10	·00011574	·0069444	·416666	3650	10

EQUIVALENT RATES.

Per Second.	Per Minute.	Per Hour.	Per Day (24 H).	Per Year.
1	60	3600	86400	31536000
·016667	1	60	1440	525600
·00027778	·016667	1	24	8760
·000011574	·000694	·041667	1	365
·0000003171	·0000019	·00011415	·0027397	1

TABLE FOR CONVERSION OF *Cubic Feet into Gallons and Gallons into Cubic Feet.*

Cubic feet.	Gallons.	Cubic feet.	Gallons.	Gallons.	Cubic feet.	Gallons.	Cubic feet.
1	6·2355	6	37·4130	1	·16037	6	·96223
2	12·4710	7	43·6485	2	·32074	7	1·12260
3	18·7065	8	49·8840	3	·48112	8	1·28298
4	24·9420	9	56·1195	4	·64149	9	1·44335
5	31·1775	10	62·3550	5	·80186	10	1·60372

Annual discharge per second and minute, uniformly spread over 12 months, from Storage Tanks having a given capacity as in 1st Column.

Capacity, Cubic Feet.	Uniform Discharge per second.	Uniform Discharge per minute.	Capacity Cubic Feet.	Uniform Discharge per second.	Uniform Discharge per minute.	Capacity, Cubic Feet.	Uniform Discharge per second.	Uniform Discharge per minute.
25	·000007927	·000047565	9000	·00028539	·0171234	1 Million.	·03171	1·9026
50	·000001585	·00009513	10000	·000317	·019026	2 ,,	·06342	3·8052
100	·00000317097	·00019026	20000	·000634	·038052	3 ,,	·09513	5·7078
200	·000006342	·00038052	30000	·000951	·057078	4 ,,	·12684	7·6104
300	·000009513	·00057078	40000	·001268	·076104	5 ,,	·15855	9·5130
400	·000012684	·00076104	50000	·001585	·095130	6 ,,	·19026	11·4156
500	·000015855	·00095130	60000	·001903	·114156	7 ,,	·22197	13·3182
600	·000019026	·00114156	70000	·002219	·133182	8 ,,	·25368	15·2208
700	·000022197	·00133182	80000	·002537	·152208	9 ,,	·28539	17·1234
800	·000025368	·00152208	90000	·002854	·171234	10 ,,	·31710	19·026
900	·000028539	·00171234	100000	·003171	·19026	31·536	1·0000	60·00
1000	·00003171	·0019026	200000	·006342	·38052	100 ,,	3·1710	190·26
2000	·00006342	·0038052	300000	·009513	·57078	200 ,,	6·3420	380·52
3000	·00009513	·0057078	400000	·012684	·76104	300 ,,	9·5129	570·78
4000	·00012684	·0076104	500000	·015855	·95130	400 ,,	12·6839	761·04
5000	·00015855	·0095130	600000	·019026	1·14156	500 ,,	15·8549	951·30
6000	·00019026	·0114156	700000	·022197	1·33182	600 ,,	19·0259	1141·56
7000	·00022197	·0133182	800000	·025368	1·52208	700 ,,	22·1969	1331·82
8000	·00025368	·0152208	900000	·028539	1·71234	800 ,,	25·3678	1522·08
						900 ,,	28·5388	1712·34
						1000 ,,	31·7970	1902·60

For Rainfall in Inches per annum the rate of accumulation on (or uniform run-off from) Acres and square miles per second, minute, or year.

Rainfall in year.	On Acre.			Rainfall in year.	On Square Mile.		
nches	Per Second.	Per Minute.	Per Annum.	Inches	Per Second.	Per Minute.	Per Annum.
1	·000115107	·0069064	3630	1	·07366819	4·4200913	2323200
2	·00023021	·0138128	7260	2	·14733638	8·8401826	4646400
3	·00034532	·0207192	10890	3	·22100457	13·2602739	6969600
4	·00046043	·0276256	14520	4	·29467276	17·6803652	9292800
5	·00057554	·0345320	18150	5	·36834095	22·1004565	11616000
6	·00069064	·0414384	21780	6	·44200914	26·5205478	13939200
7	·00080575	·0483448	25410	7	·51567733	30·9406391	16262400
8	·00092028	·05525136	29040	8	·58934552	35·3607304	18585600
9	·00103599	·06215778	32670	9	·66301371	39·7808217	20908800
10	·00115111	·0690642	36300	10	·73668190	44·2009130	23232000
11	·00126622	·0759706	39930	11	·81035009	48·6210043	25555200
12	·00138132	·0828770	43560	12	·88401828	53·0410956	27878400
13	·00149643	·0897835	47190	13	·95768647	57·4611869	30201600
14	·00161154	·0966899	50820	14	1·03135466	61·8812782	32524800
15	·00172665	·1035963	54450	15	1·10502285	66·3013695	34848000
16	·00184175	·1105027	58080	16	1·17869104	70·7214608	37171200
17	·00195686	·1174091	61710	17	1·25235923	75·1415521	39494400
18	·00207197	·12431556	65340	18	1;32602742	79·5616434	41817600
19	·00218707	·13122196	68970	19	1·39969561	83·9817347	44140800

Quantities of Water in Cubic Feet and Gallons, on Acres and Square Miles, equivalent to Rainfall in Inches.

Inches of Rain.	On Acre.		On Square Mile.		Inches of Rain.
	Cubic Feet.	Gallons.	Cubic Feet.	Gallons.	
1	3630	22635	2323200	14486314	1
2	7260	45270	4646400	28972627	2
3	10890	67905	6969600	43458941	3
4	14520	90539	9292800	57945254	4
5	18150	113174	11616000	72431568	5
6	21780	135809	13939200	86917882	6
7	25410	158444 c	16262400	101404195	7
8	29040	181079	18585600	115890509	8
9	32670	203714	20908800	130376822	9
10	36300	226349	23232000	144863136	10
11	39930	248984	25555200	159349450	11
12	43560	261619	27878400	173835763	12

Rate of Accumulation or Run-off per Second, Minute, Hour or Day, per Acre or Square Mile, for Rainfall in Inches per Day and Hour.

Rainfall.		Cubic feet on Acre per				Cubic feet on Square Mile per			
Per Day, Inches.	Per Hour, Inches.	Second.	Minute.	Hour.	Day (24 H)	Second.	Minute.	Hour.	Day (24 H)
1	$\frac{1}{24}$	·0420129	2·52083	151·25	3630	26·8883	1613·333	96800	2323200
2	$\frac{1}{12}$	·0840258	5·04166	302·50	7260	53·7766	3226·66	193600	4646400
3	$\frac{1}{8}$	·1260387	7·56249	453·75	10890	80·6659	4839·99	290400	6969600
4	$\frac{1}{6}$	·1680516	10·08332	605·00	14520	107·5532	6453·33	387200	9292800
5	$\frac{5}{24}$	·200645	12·60416	756·25	18150	134·4415	8066·66	484000	11616000
6	$\frac{1}{4}$	·2520774	15·12499	907·50	21780	161·3298	9679·99	580800	13939200
7	$\frac{7}{24}$	·2940903	17·64583	1058·75	25410	188·2189	11293·33	677600	16262400
8	$\frac{1}{3}$	·3361032	20·16666	1210·00	29040	215·1064	12906·66	774400	18585600
9	$\frac{3}{8}$	·3781161	22·68749	1361·25	32670	241·9947	14519·99	871200	20908800
10	$\frac{5}{12}$	·4201290	25·2083	1512·50	36300	268·8883	16133·33	968000	23232000
11	$\frac{11}{24}$	·4621420	27·7288	1663·75	39930	295·7713	17746·66	1064800	25555200
12	$\frac{1}{2}$	·504155	30·2500	1815·00	43560	322·6596	19359·99	1161600	27878400
18	$\frac{3}{4}$	·7562324	45·3750	2722·50	65340	483·9894	29039·99	1742400	41817600
24	1	1·0083098	60·5000	3630	87120	645·3192	38719·99	2323200	55756800
48	2	2·0166196	121·0000	7260		1290·6384	77439·98	4646400	
72	3	3·0249294	181·5000	10890		1935·9576	116159·97	6969600	
96	4	4·0332392	242·0000	14520		2581·2768	154879·96	9292800	
120	5	5·041535	301·5000	18150		3226·5960			
144	6	6·049858	362·9915	21778					

Table of Totals of Units per Second up to 31 Days and for 1 Year.

Days.	Units per Second such as Cubic Feet, &c.								
	1	2	3	4	5	6	7	8	9
1	86400	172800	259200	345600	432000	518400	604800	691200	777600
2	172800	345600	518400	691200	864000	1036800	1209600	1382400	1555200
3	259200	518400	777600	1036800	1296000	1555200	1814400	2073600	2332800
4	345600	691200	1036800	1382400	1728000	2073600	2419200	2764800	3110400
5	432000	864000	1296000	1728000	2160000	2592000	3024000	3456000	3888000
6	518400	1036800	1555200	2073600	2592000	3110400	3628800	4147200	4665600
Week 7	604800	1209600	1814400	2419200	3024000	3628800	4233600	4838400	5443200
8	691200	1382400	2073600	2764800	3456000	4147200	4838400	5529600	6220800
9	777600	1555200	2332800	3110400	3888000	4665600	5443200	6220800	6998400
10	864000	1728000	2592000	3456000	4320000	5184000	6048000	6912000	7776000
11	950400	1900800	2851200	3801600	4752000	5702400	6652800	7603200	8553600
12	1036800	2073600	3110400	4147200	5184000	6220800	7257600	8294400	9331200
13	1123200	2246400	3369600	4492800	5616000	6739200	7862400	8985600	10108800
14	1209600	2419200	3628800	4838400	6048000	7257600	8467200	9676800	10886400
15	1296000	2592000	3888000	5184000	6480000	7776000	9072000	10368000	11664000
16	1382400	2764800	4147200	5529600	6912000	8294400	9676800	11059200	12441600
17	1468800	2937600	4406400	5875200	7344000	8812800	10281600	11750400	13219200
18	1555200	3110400	4665600	6220800	7776000	9331200	10886400	12441600	13996800
19	1641600	3283200	4924800	6566400	8208000	9849600	11491200	13132800	14774400
20	1728000	3456000	5184000	6912000	8640000	10368000	12096000	13824000	15552000
21	1814400	3628800	5443200	7257600	9072000	10886400	12700800	14515200	16329600
22	1900800	3801600	5702400	7603200	9504000	11404800	13305600	15206400	17107200
23	1987200	3974400	5961600	7948800	9936000	11923200	13910400	15897600	17884800
24	2073600	4147200	6220800	8294400	10368000	12441600	14515200	16588800	18662400
25	2160000	4320000	6480000	8640000	10800000	12960000	15120000	17280000	19440000
26	2246400	4492800	6739200	8985600	11232000	13478400	15724800	17971200	20217600
27	2332800	4665600	6998400	9331200	11664000	13996800	16329600	18662400	20995200
One Month. 28	2419200	4838400	7257600	9676800	12096000	14515200	16934400	19353600	21772800
29	2505600	5011200	7516800	10022400	12528000	15033600	17539200	20044800	22550400
30	2592000	5184000	7776000	10368000	12960000	15552000	18144000	20736000	23328000
31	2678400	5356800	8035200	10713600	13392000	16070400	18748800	21427200	24105600
One Year 365	31536000	63072000	94608000	126144000	157680000	189216000	220752000	252288000	283824000

SUPPLY TO TOWNS.

Population supplied at Rate of 1 Gallon per head per diem.	Cubic Feet storage for 1 year supplied at rate in 1st column.	Equivalent uniform discharge in cubic feet per second throughout year.
1000	58536	·0018561
2000	117072	·0037122
3000	175608	·0055683
4000	234144	·0074244
5000	292680	·0092806
6000	351216	·0111367
7000	409752	·0129929
8000	468288	·0148980
9000	526824	·0166951
10000	585362	·0185612
20000	1170723	·0371224
30000	1756085	·0556836
40000	2341446	·0742449
50000	2926808	·0928061
60000	3512169	·1113673
70000	4097531	·1299285
80000	4682893	·1484897
90000	5268254	·1670510
100000	5853616	·18561224

TABLE TO CONVERT

Pounds per S. I. to Tons per S. F.

Pounds on		Tons on	
S. I.	S. F.	S. I.	S. F.
1	144	·000446	·064286
2	288	·000893	·12857
3	432	·001339	·19285
4	576	·001786	·25714
5	720	·002232	·32142
6	864	·002678	·38570
7	1008	·003125	·45000
8	1152	·003571	·51427
9	1296	·004018	·57855
10	1440	·004464	·64286
11	1584	·004911	·70714
12	1728	·005357	·77143
13	1872	·005804	·83572
14	2016	·006250	·90000
15	2160	·006696	·96428
16	2304	·007143	1·02857
17	2448	·007590	1·09285
18	2592	·008036	1·15714
19	2736	·008432	1·22142
20	2880	·008928	1·2857
30	4320	·013393	1·9285
40	5760	·01786	2·5714
50	7200	·02232	3·2143
60	8640	·02678	3·8570
70	10080	·03125	4·4948
80	11520	·03571	5·1427
90	12960	·04018	5·7856
100	14400	·04464	6·4286

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INDEX.

A.

Page

Alloy that expands in cooling (note on) 342
Ants, white, lotion for (note on) 343
Aqueducts, to stop leakage in (note on) 292
Arch, concrete (note on) 296
„ Quoins (note on) 319
„ Rings and Segments, areas of, for certain spans of definite rise, Tables LXXXII to LXXXIV 508 to 510
„ „ „ „ in terms of span; Table LXXXI ... 507
„ „ „ description of Tables of 454
Ashlar (general specification) 20
Ashlar, Arching, (specification) 21, 67
„ „ (rate) 89
„ Chamfered (specification) 60
„ „ (rate) 73
„ Facing (specification) 60
„ „ (rate) 74
„ Fine (specification) 59
„ „ (rate) 71
„ Rock, Rustic, or Quarry-faced (specification) 59
„ „ „ „ (rate) 73
„ Rough-tooled (specification) 59
„ „ (rate) 72
Ashlar Walling (general specification) 20
Asphalt (note on) 298

B.

Beton Pisé (note on) 297
Blocks (note on) 327
Block in course masonry (specification) 60
„ „ „ (rate) 76
„ „ Arching (specification) 68
„ „ „ (rate) 90
„ „ Facing (specification) 61
„ „ „ (rate) 76
Boring (note on) 322
Brass Lacquer (note on) 310
„ Lacquered, to clean (note on) 310
Bricks, colouring, by dipping (note on) 288
„ flooring (note on) 295
„ laying (note on) 289
Brick and Mud Work (specification) 66
„ „ „ (rate) 87
„ and tile making (general specification) 15
„ Arching for Bridges (specification) 68
„ „ „ (rate) 92
„ „ over Doors and Windows, 1st Class (specification) ... 69
„ „ „ „ „ (rate) 92
„ „ „ „ 2nd Class (specification) ... 69
„ „ „ „ „ (rate) 93
„ in chunam (general specification) 16
„ in mud (general specification) 18
„ making (general specification) 15
„ „ on Ground (rate) 272
„ „ on Tables (rate) 271
„ Nogging (specification) 67

	Page
Brick Nogging (rate)	88
„ „ and Teak Posts (note on)	289
„ Work (general specification)	16
„ „ 1st Class (specification)	66
„ „ „ (rate)	85
„ „ 2nd Class (specification)	66
„ „ „ (rate)	86
Bridges, B. B. & C. I. Railway (note on)	318
„ Part II. (notes on)	384
„ „ Appendix, Wing walls	406
„ „ „ Table G., foundation and superstructure of wing walls	407
„ „ „ „ H., foundation of wing walls splayed ...	409
„ „ „ „ I., superstructure of do. ...	410
„ „ „ „ J., returned walls foundation and superstructure	411
„ „ „ „ K., length of wing walls	412
„ „ „ „ L., area of Pitching	413
„ „ Quantities in, on roads 20 feet wide for all formation heights, Table I.	391
„ „ „ in a vertical section one foot in length for all formation heights, Table II.	401

C.

Canal Banks (specification)	55
Carriage (general specification)	1
Carts, conveyance by ; Table XXVIII	451
Ceilings, Cloth (specification)	153
„ „ (rate)	159
„ Lath and Plaster (specification)	153
„ „ „ (rate)	160
„ Plank (specification)	153
„ „ (rate)	157
„ „ with joists (specification)	153
„ „ „ (rate)	158
Cement, China and Glass (note on)	341
„ D. O'Shaughnessy's (note on)	292
„ Durable (note on)	290
„ Glue (note on)	291
„ Oil (note on)	290
„ Mortar (general specification)	12
„ Portland (general specification)	12
„ „ (note on)	293
„ Red Lead, for face joints (note on)	291
„ Rust joint, quickly setting (note on)	290
„ „ slowly „ (note on)	291
„ Skin, Portland, over concrete (note on)	294
„ useful (note on)	290
„ Waterproof Mastic (note on)	290
Chimneys, factory (note on fixing lightning conductors)	311
Clearing of Site (general specification)	1
Collieries, protection of, by Lightning Conductors (note on)	312
Colour-washing (note on)	308
Concrete (general specification)	13
„ Cement (specification)	69
„ „ (rate)	96
„ for Sea-works (note on)	292
„ in Dams (specification)	51
„ of Broken Brick and Kunkur (specification)	69
„ „ „ (rate)	95
„ of Shingle or Road metal (specification)	69
„ „ „ (rate)	94

	Page
Coolies, conveyance by ; Table XXVII.	450
Copings and String-courses (specification)	243
Coping, cutstone, rectangular 1st Sort (rate)	249
„ „ „ 2nd Sort (rate)	250
„ „ semicircular, 1st Sort (rate)	253
„ „ „ 2nd Sort (rate)	254
„ „ semi-octagonal, 1st Sort (rate)	251
„ „ „ 2nd Sort (rate)	252
Culverts	355
„ Timber-topped, Iron-work for ; Table XXIV	443
„ „ Scantling for ; Table XXIII	440

D.

Dams of Earth-work, Large Reservoir (specification)	47
„ Masonry (specification)	50
Dismantling of Building (general specification)	1
Door Frames ; scantlings of Table V	423
„ and Window Frames (specification)	129
Doors, Batten ; scantlings of, Table VIII	426
„ Framed and Braced (specification)	131
„ „ „ (rate)	139
„ „ „ Scantlings of, Table IX	427
„ „ Batten ; scantlings of, Table X	428
„ Iron-barred with planked Shutters (specification	131
„ „ „ ... (rate)	140
„ Ledged (specification)	130
„ „ (rate)	138
„ Panelled, 1st Class (specification)	129
„ „ „ (rate)	134
„ „ 2nd Class (specification)	129
„ „ „ (rate)	135
„ „ Scantlings of, Table VI.	424
„ „ and Glazed, 1st Class (specification)	130
„ „ „ „ (rate)	136
„ „ „ 2nd Class (specification)	130
„ „ „ „ (rate)	137
„ „ „ Scantlings of, Table VII	425
„ Venetianed, 1st Class (specification)	131
„ „ „ (rate)	141
„ „ 2nd Class (specification)	132
„ „ „ (rate)	142
Down pipes (specification)...	180
Drainage of Buildings (general specification)	42
Drains, slab	355
„ and Culverts (notes on)	349
„ „ Part I.	378
„ „ „ Appendix, Wing walls	378
„ „ „ „ Table A., foundation of wing walls.	380
„ „ „ „ „ B. superstructure of do.	381
„ „ „ „ „ C., length of coping of do.	382
„ „ „ „ „ D., contents of counter forts .	382
„ „ „ „ „ E., segmental quantities ...	382
„ „ „ „ „ F., cut waters	383
„ „ Quantities in, for road 20 feet wide for all formation heights, Table I.	363
„ „ „ in a vertical Section, one foot in length for all formation heights, Table II. ...	371
Drawing-paper, size of (note on)	341
„ Temporarily restoring (note on)	340
Dry Rubble Works (general specification)	23
„ Stone Pitching (general specification)	23
„ „ Revetments (general specification)	23

	Page
Dryers (note on)	306
Dynamite, Instructions for using (note on)	333

E

Earth, loose or sand, excavation in (rate)	233
Earth-work (general specification)	2
„ Tables, description of	452
„ „ First Series, XXIX to XLVIII ...	455 to 474
„ „ Second Series, XLIX to LXXX ...	475 to 506
„ „ First Series, exemplification of	453
„ „ Second Series do.	453
Engines, Portable, directions for use	312
Etching on Glass (note on)	343
Ecavation in Black or Red soil (rate)...	229
„ in soft Moorum (rate)	230
„ in Average Moorum (rate)	231
„ in Hard Moorum (rate)	232
„ in Loose Earth or Sand (rate)	233
„ in Soft Rock (rate)	234
„ in Hard Rock (rate)	234

F

Fencing, Wire (rate)	276
Floor, Brick or Tiled (specification)	100
„ „ laid flat (rate)	113
„ „ laid on edge (rate)	114
„ Minton's Tiles (specification)	102
„ „ „ (rate)	118
„ Planking (specification)	103
„ „ (rate)	120
Floors, Chunam or terraced (specification)	100
„ „ „ (rate)	115
„ Mosaic, laying (note on)	299
„ to utilize broken Tiles in Pattern (note on)	299
Flooring (general specification)	33
„ Asphalt (general specification)	34
„ „ (specification)	100
„ „ (rate)	116
„ Bastard Asphalt (specification)	101
„ „ „ (rate)	117
„ Brick on edge (general specification)	33
„ Cement concrete (general specification)	33
„ Chunam or Terraced (general specification)	33
„ Composite No. 1 (specification)	104
„ „ „ (rate)	124
„ „ No. 2 (specification)	105
„ „ „ (rate)	126
„ Double (specification)	104
„ „ weight supported 140 lbs. per square foot (rates) ...	122
„ „ „ „ 168 lbs. „ (rates) ...	123
„ Minton's Tiled (general specification)	34
„ for Road Bridges (note on)	319
„ single (specification)	103
„ „ weight supported 140 lbs. per square foot (rates) ...	121
„ „ „ „ 168 lbs. „ (rates) ...	121
„ stone (general specification)	34
„ Tar and sand (general specification)	34
„ Tile or square Brick (general specification)	33
„ Wooden, (general specification)	34
„ „ for Ground Floors (specification)	102
„ „ „ „ (rate)	119

Page
Foundations (general specification) 25
Fumigation with Chlorine Gas (note on) 342
„ „ Nitric Oxide Gas (note on) 342
„ „ Sulphurous Acid Gas (note on) 342

G

Girders, Iron, erection of (note on) 319
„ Teak, Scantlings of; weight supported 140 lbs. per square foot; Table III. 422
Girders, Teak, Scantlings of; weight supported 168 lbs. per square foot; Table IV. 422
Glass Opaque, to render (note on) 342
Glazier's work (general specification) 41
Glazing (specification) 246
Glue (note on) 291
„ Liquid (note on) 291
„ Marine (note on) 291
Glues, quick drying (note on) 291
Gold Lacquer (note on) 310
Grassing, Turfing or sodding (general specification) 6
Gyn or Tripod Trestle, to form (note on) 328

H

Hydraulic Cement (note on) 298
„ Lime, artificial (note on) 293

I

Insulators (note on) 310
Iron-work (general specification) 85
Iron-work, ornamental (note in connection with lightning conductor) ... 311
Irrigation, useful memoranda and Tables .... 511 to 519

J

Joists, Teak, Scantlings of; weight supported 140 lbs. per square foot; Table I... 421
„ „ „ „ „ 168 lbs. per square foot; Table II... 421

K

Knot, Bowline (note on) 326
„ „ on a Bight (note on) 326
„ Carrick Bend (note on) 326
„ Cat's Paw (note on) 326
„ Clove Hitch (note on) 325
„ Double Sheet Bend (note on) 325
„ Draw (note on) 325
„ Figure of 8 (note on) 324
„ Fisherman's Bend (note on) 325
„ Reef (note on) 324
„ Round Turn and Two Half-Hitches (note on) 325
„ Sheep Shank (note on) 325
„ Single Sheet Bend (note on) 325
„ Slip or Hangman's (note on) 327
„ Stopper Hitch (note on) 326
„ Thumb or Overhand (note on) 324
„ Timber Hitch (note on) 326
„ Two Half-Hitches (note on) 325
„ Wall (note on) 327

Page

L

Labels, Wooden, to preserve (note on) 342
Laterite and Lime Foundations (rate) 277
„ „ Plinth (rate) 278
„ Arching over Doors and Windows (rate) 280
„ Concrete (rate) 284
„ Coping, semi-octagonal top 8" high (rate) 283
„ Cornice 8" high (rate) 282
„ Metal from Boulders (rate) 284
„ Paving (rate) 281
„ Superstructure, Block-in-course (rate) 279
Lead, red (note on) 307
Leather Preservative (note on) 341
Leather-work, cleaning (note on) 341
Lightning Conductor (specification) 181
„ „ connection with extensive masses of Metal (note on) 312
„ „ Curvature of (note on) 311
„ „ Earth connection of (note on) 312
„ „ for Factory Chimneys 311
„ „ Fixing (note on) 311
„ „ Insulators for (note on) 310
„ „ Inspection of (note on) 312
„ „ Joints of (note on) 311
„ „ Materials for (note on) 311
„ „ Painting of (note on) 311
„ „ Points of (note on) 310
„ „ Protection of (note on) 311
„ „ Protection of collieries by (note on) 312
„ „ Upper Terminals of (note on) 310
Lime (general specification) 10
„ Burning with Charcoal (rate) 273
„ „ with English Coal (rate) 275
„ „ with Firewood (rate) 274
„ Mortars and Cement (general specification) 10

M.

Masonry Dry Stone (specification) 65
„ „ „ (rate) 83
„ in Canal Drainage Works (specification) 52
„ Stone and Mud (specification) 65
„ „ „ (rate) 82
Metal, carrying and stacking (rate) 238
„ collection of (general specification) 7
„ consolidating, with ordinary rollers (rate) 239
„ „ with steam rollers (rate) 240
„ extensive masses of, connection with lightning conductor (note on) ... 312
„ from Blasted Rubble, quarrying and breaking (rate) 237
„ from Boulders, quarrying and breaking (rate) 237
„ spreading and consolidating (general specification) 8
„ spreading and picking up surface (rate) 239
„ work (general specification) 35
„ „ erection (general specification) 35
„ „ general (general specification) 35
„ „ Iron work (general specification) 35
Moorum, average, excavation in (rate) 231
„ Digging, conveying and spreading for road surface (rate) ... 235
„ Hard, excavation in (rate) 232
„ Soft „ (rate) 230
„ Watering and Rolling (rate) 236
Mortar (general specification) 11
Cement (general specification) 12

	Page
Mortar, Grinding (rate)	270
„ Hydraulic lime and sand (general specification)	12
„ Mogul (note on)	290
„ Pumice (general specification)...	12

P.

Painter's Work (general specification)	37
Painting (specification)	244
„ (rate)...	256
„ (note on)	306
„ old word (note on)	307
Papering (specification)	245
Paving, 1st Sort (specification)	99
„ „ (rate)	107
„ 2nd Sort (specification)	99
„ „ (rate)	108
„ 3rd Sort (specification)	99
„ „ (rate)	109
„ 4th Sort (specification)	99
„ „ (rate)	110
„ for Upper Story, 1st Sort (specification)	100
„ „ „ (rate)	111
„ „ 2nd Sort (specification)	100
„ „ „ (rate)	112
Pigments (note on)	307
Pile Driving (note on)	319
Pipe Laying (note on)	320
Pipes, Cast Iron, Laying (specification)	55, 246
„ „ „ 10″ diameter (rate)	266
„ „ „ 6″ „ (rate)	267
„ „ „ 4″ „ (rate)	268
„ „ „ 3″ „ (rate)	269
„ Earthenware (note on)	321
„ Iron, solution for coating (note on)	321
Pisé work (general specification)	14
„ Mud Plaster (general specification)	15
„ (note on)	295
Plaster (general specification)	24
„ Brick-rubbed rough (specification)	155
„ „ „ (rate)	163
„ Madras (note on)	290
„ work (general specification)	24
„ „ Cement (general specification)	25
„ „ rough casting (general specification)	24
Plastering, Cement (specification)	155
„ „ (rate)	164
„ Fine coat (rate)	162
„ Rough ¾″ thick (specification)	154
„ „ „ (rate)	161
„ „ cast ½″ thick (specification)	155
„ „ „ (rate)...	163
Plumber's work (general specification)	42
Pointing, Cement (specification)	156
„ „ (rate)	166
„ Lime (specification)	155
„ „ Brick Masonry (rate)...	165
„ „ Masonry (rate)	165
Polish, French (note on)	309
Posts, Verandah (note on)...	303
Price per cubic foot of buildings by War Department (note on) ...	340
„ „ of Government Buildings by Public Works Department (note on)	340

	Page
Pumice mortar (general specification)...	12
Pumps, Centrifugal, Gwynne's (note on)	322
Purlins, Scantlings of ; Table XVIII...	436

Q.

Quarrying and Blasting (general specification)	

R.

Racquet Courts, size of (note on)	340
Rafters, Common, Scantlings of ; Table XVIII	436
„ Hip „ „ „	436
„ Jack „ „ „	436
„ Principal „ „ „	436
Retaining-walls, Dry Rubble (specification)	65
„ „ (rate)	84
Revetment, ghaut, rough-stone (general specification)	23
Road Project, Plans and Office work	415
„ Survey and Field work	413
Road-work (general specification)	7
„ Maintenance (general specification)	9
„ Metal, collection of (general specification)	7
„ Spreading and consolidation (general specification) ...	8
Rock, Hard, Excavation in (rate)	234
„ Soft „ (rate)	234
Roof, Dammering on (specification)	179
„ Syrian, as used in Sind (specification)	178
Roofs, Terraced, to fill cracks in (note on)	291
„ Verandah, Scantlings of ; Table XIX, Double-tiled	437
„ „ „ Table XX, Single-tiled	438
Roof-covering, Atkinson's Tiles (specification)	177
„ „ Belgaum (specification)	175
„ „ „ (rate)	219
„ „ Double-tiled (specification)	170
„ „ „ (rate)	182
„ „ „ Eaves board (rate)	185
„ „ „ Setting Eaves in Chunam (specification) ...	170
„ „ „ Setting Double Eaves in Chunam (rate) ...	184
„ „ „ Setting Hips in and Ridges in Chunam (specification)	170
„ „ „ Setting Hips and Ridges in Chunam (rate) ...	183
„ Down Pipes (specification)	180
Roof-covering, Galvanized, Corrugated Iron (specification)	172
„ „ „ „ (rate)	205
„ „ „ „ Fixing Ridge (rate)	207
„ „ „ „ Rivetting and Fixing Sheets (rate) ...	206
„ „ Table showing the arrangement of sheets	208
„ „ Galvanized Iron (note on)	305
„ „ Goodwyn's Tiles (specification)	177
„ „ Gutters, Valleys and Flashings (specification) ...	179
„ „ „ and Valleys of Sheet Lead (rate)	224
„ „ Hill's Tiles (specification)	178
„ „ Mangalore Tiles (specification)	177
„ „ „ „ (rate)	222
„ „ „ „ Hips and ridges (specification) ...	177
„ „ „ „ „ „ (rate)	223
„ „ Oropholite (specification)	179
„ „ Ridge Ventilators, Howard's Pattern (specification) ...	180
„ „ Taylor's Patent Tiles (specification)	175
„ „ „ „ „ (rate)	220
„ „ „ „ „ Hips and ridges (specification) ...	176
„ „ „ „ „ „ (rate) ...	221

41

	Page
Roof-covering, Valleys of Sheet Iron (rate)	225
" " Wood Cement (specification)	178
" " Zinc (general specification)	32
" " Zinc (specification)	175
Roofing (general specification)	28
" (specification)	169
" Concrete Arched (notes on)	329
" Corrugated Iron (general specification)	31
" " " (specification)	172
" " " XII feet span (rate)...	209
" " " XIV " (rate)...	210
" " " XVI " (rate)...	211
" " " XVIII " (rate)...	212
" " " XX " (rate)...	213
" " " XXII " (rate)...	214
" Double Tiled (general specification)	29
" " ordinary construction (specification)	170
" " " XII feet span (rate) ...	186
" " " XIV " (rate) ...	187
" " " XVI " (rate) ...	188
" " " XVIII " (rate) ...	189
" " " XX " (rate) ...	190
" " " XXII " (rate) ...	191
" " " XXIV " (rate) ...	192
" " " XXVI " (rate) ...	193
" " " XXVIII " (rate) ...	194
" " " XXX " (rate) ...	195
" " Purlin-rafter Construction (specification)... ...	171
" " " " XII feet span (rate) ...	199
" " " " XIV " (rate) ...	200
" " " " XVI " (rate) ...	201
" " " " XVIII " (rate) ...	202
" " " " XX " (rate) ...	203
" " " " XXII " (rate) ...	204
" Mangalore Tiling (general specification)	30
" Sheet Iron Galvanized, continuous (general specification) ...	31
" Shingle (general specification)	32
" Tar and sand for Terraced Roofs (general specification) ...	32
" Terraced (specification)	173
" " VIII feet span (rate)	215
" " XII " (rate)	216
" " XVI " (rate)	217
" " Fire-proof (specification)	174
" " " (rate)	218
" Terracing, arched (general specification)...	29
" " Pucka (general specification)	28
" Thatched (general specification)	30
" Verandah, Double Tiled (specification)	171
" " " VI feet span (rate)	196
" " " VIII " (rate)	197
" " " X " (rate)	198
Rubble Arching (specification)	68
" " (rate)	91
" Coursed, 1st Sort (specification)	61
" " " (rate)	77
" " 2nd Sort (specification)	62
" " " (rate)	78
" " 3rd Sort (specification)	63
" " " (rate)	79
" Random, 1st Sort (specification)	63
" " " " (rate)	80
" " 2nd sort (specification)	64
" " " (rate)	80

Page

Rubble, Uncoursed (specification) 64
„ (rate) 81

S.

Saddlery, cleaning (note on) 341
Sand (general specification) 11
„ Boxes, Bridge (note on) 319
„ Excavation in (rate)... 233
Sanitation of working parties (note on) 337
Screws, Metal, or Bottle Stoppers, to remove (note on) 341
Segments and Arch Rings, Areas of, for certain spans of definite rise ; Tables LXXXII to LXXXIV...508 to 510
„ „ „ in terms of span ; Table LXXXI. ... 507
„ „ Description of Tables of... 454
Sheers, to form a pair of Temporary (note on) 328
Sites, cleaning of (general specification) 1
Soil, Black, Excavation in (rate) 229
„ Red „ (rate) 229
Solvents (note on) 307
Stairs, Stone (specification) 243
„ „ (rate) 255
Stair-case, Wooden (specification) 244
„ „ (rate)... 255
Steel, to harden (note on) 341
Steps, Stone (specification) 243
„ „ (rate) 255
Stone, Basalt, Blue or Trap (note on)... 287
„ „ Bombay (note on) 287
„ „ Red (note on) 287
„ „ Yellow (note on) 287
„ Granite (note on) 287
„ Hemnuggur (note on) 287
„ Laterite (note on) 287
„ Limestone (note on)... 287
„ Porebandar (note on) 287
„ Dressed (general specification) 22
„ Flagging (general specification)... 22
„ Masonry (general specification) 19
„ „ Ashlar (general specification) 20
„ „ Ashlar Arching (general specification) 21
„ „ „ Facing (general specification) 20
„ „ „ Walling (general specification) 20
„ „ Ordinary stone or rubble-work (general specification) ... 21
„ Work, coursed (general specification) 22
Straps and Bolts, dimension of ; Table XXII. 439
String-courses and Copings (specification) 243
String-course, Cutstone, 1st Sort (rate) 247
„ „ 2nd Sort (rate) 248
Sun-dried Brick in Mud (general specification) 18
Surki (general specification) 11

T.

Tackles (note on) 327
Taskworks, Burke's Table XXV. 445
„ in different soils ; Table XXVI. 448
„ Memo. explanatory to the above tables 444
Terra Cotta (note on) 288
Tile-making (rate) 270
„ Skirtings (specification) 246
Transom to an upright spar, to lash (note on) 328

	Page
Tree, Arjun (note on)	301
„ Australian Gum (note on)	301
„ Babul (note on)	300
„ Bakool (note on)	301
„ Blackwood (note on)...	300
„ Cedar (note on)	301
„ Honagi (note on)	301
„ Honay (note on)	301
„ Hurda (note on)	302
„ Jack (note on)	302
„ Jamba (note on)	301
„ Jarrak, or Australian Mahogany (note on)	301
„ Kalamb (note on)	302
„ Mango (note on)	302
„ Mutti (note on)	301
„ Pine (note on)	301
„ Sirris (note on)	302
„ Tamarind (note on)	302
„ Teak (note on)	301
„ Unjun (note on)	300
Trellis Work, Hoop Iron (specification)	246
„ „ (rate)	264
„ in Chunam (note on)	300
„ Teak-wood (specification)	246
„ „ (rate)	265
Trusses, Iron (note on)	303
„ „ Table of Dimensions of...	304
„ Teak (note on)	303
„ „ scantlings of ; Table XVII.	435
„ „ for Corrugated Iron Roofs, Scantlings of ; Table XXI. ...	439

V.

Varnish for name-boards, labels, &c. (note on)	343
Varnishes (note on)	309
Varnishing (specification)	245
„ (rate)	257
Venetian Blinds (note on)...	305

W.

Wall-plates, Scantlings of ; Table XVIII.	436
Walls, Concrete (note on)	297
„ Hollow (note on)	289
„ Tiled (note on)	289
Wash, Blue (rate)	260
„ Green (rate)	262
„ Pink (rate)	261
„ Yellow (rate)	259
Water, drinking, to purify (note on)	341
Water-proof Mixture (note on)	342
Well-sinking (general specification)	27
„ for Foundation (general specification)	28
„ for supply of water (general specification)	27
White-washing (rate)	258
„ and Colour-washing (specification)	245
Window Frames ; scantlings of ; Table XI.	429
„ „ Iron Barred, scantlings of ; Table XII.	429
Windows, Batten, scantlings of ; Table XV.	433
„ Glass and Venetianed Shutters, 1st Class (specification) ...	133
„ „ „ „ „ (rate)	147
2nd Class (specification) ...	133
(rate)	148

Pag

Windows, Glazed, 1st Class (specification) 13
" " " (rate) 14
" " 2nd Class (specification) 13
" " " (rate) 14
" " scantlings of; Table XIII. 43
" " Iron Barred and plank Shutters (specification) ... 13
" " " " ... (rate) 14
" " " scantlings of; Table XVI 43
" Iron-barred with plank Shutters (specification) 13
" " " " ... (rate) 14
" Plank Shutters (specification) 13
" " " (rate) 14
" Venetianed, scantlings of; Table XIV... 43
Wing-walls (note on) 31
Wire-netting, Galvanized Iron (rate) 26
Woods principally used in Bombay Presidency (note on) 30
Wood-work (general specification) 44

Z.

Zinc, to write on (note on) 34
" White (note on) 30

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